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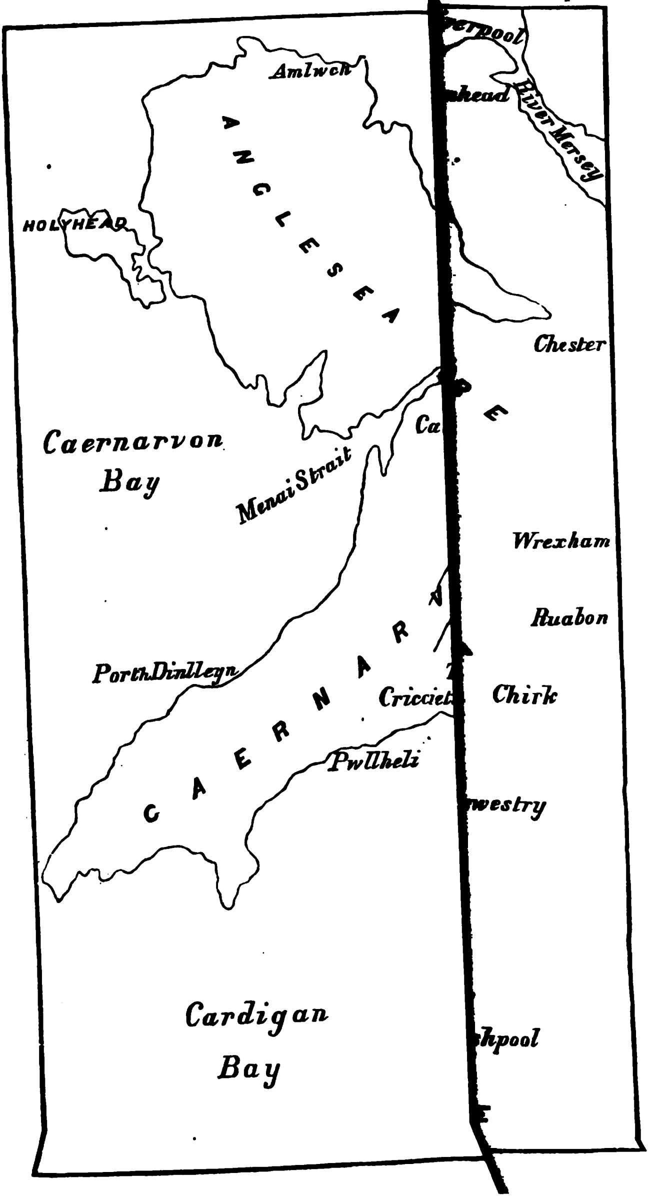

A TREATISE

ON

ATE AND SLATE QUARRYING

SCIENTIFIC, PRACTICAL, AND COMMERCIAL

BY

D. C. DAVIES, F.G.S.

MINING ENGINEER: EXAMINER OF MINES, QUARRIES, AND COLLIERIES
AUTHOR OF 'A TREATISE ON METALLIFEROUS
MINERALS AND MINING' ETC.

Second Edition, revised

Capio Lumen

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PREFACE TO THE SECOND EDITION.

THE manner in which the first edition of this book has been received both by the Press and the public, besides being gratifying to myself, shows the necessity there was for a work of the kind.

During the last eighteen months the slate trade has passed through a severe depression. Happily, while it was the last branch of industry to succumb to the badness of the times, it is one of the first to show signs of revival.

It is plain, I think, that while North Wales will continue to own the supremacy as a slate-producing country, she will not possess the monopoly of the industry in the future. My hope is that both masters and men will do their best to retain and extend the importance of this truly British industry.

D. C. DAVIES.

EBNAL LODGE, *near* OSWESTRY:
August 1880.

PREFACE.

I HAVE STRIVEN in the following pages to place in as clear and concise a form as possible the substance of our knowledge on Slate and Slate Quarrying. The great and increasing importance of the subject, and of the trade connected with it, seemed to me to demand that some such attempt should be made in which the question should be treated alike with greater comprehensiveness and more minuteness of detail than it has hitherto received. I hope my endeavour to accomplish this may prove successful, and that the book may be of value and use to all those who are interested, either scientifically, commercially, or professionally, in the subject of which it treats. The practical man will not, I hope, be the worse for reading so much of science as the book contains, and the scientific man will not, I am sure, despise the combination of science with practice which is here attempted. Both sides of the subject should be interesting to the engineer; and to the younger aspirants to that profession in its various branches the book may, I hope, be found especially useful. My desire has been to make it a permanently useful book of reference, and I trust the tables and estimates it contains may prove as useful and reliable as I have sought to make them. Besides my own personal knowledge of the subject I have gladly availed myself of help wherever it could be obtained. My thanks are especially due to my many friends among quarry owners and managers for the generous aid they have given me, and they will not, I hope, suspect me of any want of courtesy to them because I do not individually mention their names. The literature on the subject is but scanty, and it may be thus briefly described:—

Besides the references to it that are contained in larger works, such as Davies' 'Report on North Wales,' Ramsay's 'Geology of North Wales,' Hull's 'Building Stones of Great Britain,' De La Beche's 'Geological Report on Cornwall and Devon,' Sedgwick's various memoirs, and similar books, five pamphlets have been specially devoted to the description of slate and slate quarries during the last twenty years. Of these the four first were reprints of letters that had appeared in the 'Mining Journal,' and the fifth a reprint of similar letters contributed to a local newspaper.

The first of these, 'Slate Quarries in Wales,' by Thomas Cooper Smith, appeared in 1860, and the interest shown in the subject is evidenced by the fact that three editions of five thousand each were exhausted in about five years. The design of the pamphlet is to show the eligibility of slate quarries as an investment, but it also contains some interesting special information relative to particular quarries.

'Slate Quarries as an Investment' is the title of a similar pamphlet issued in 1865 by John Bower, D.C.L., Barrister-at-law. A considerable portion of this pamphlet is occupied with the effort to show the superiority of slate quarries to collieries as an investment. It also has reference to terms of lease, and the means of finding a quarry.

'The Slate Trade of North Wales,' by 'Joseph Kellow, quarry engineer, and twenty years of practical experience,' published in 1868, is replete with admonitions and cautions with respect to quarry managers, to whom it gives useful directions as to the opening out of chambers, with other practical details.

By far the ablest of these pamphlets is that of S. R. Pattison, F.G.S. 'Slate and Slate Quarries Geologically and Commercially Considered.' Mr. Pattison is known in London as a good geologist and a good lawyer, with a special knowledge of mining matters, and his pamphlet is eminently scientific and practical as far as it goes. It is also, as we should expect, free from the absurd, if it were not also mischievous, plan of 'pitting' practical against scientific knowledge, which too often disfigures books on mining matters.

'The Slate Quarries of North Wales,' published in 1873, is a reprint of a very readable series of letters contributed by an unknown author to the 'Carnarvon Herald.' The writer had visited most of the quarries in North Wales in the interest of the paper, and the result is a large amount of special information relative to particular quarries, and to the social condition of the quarry-men, all of which is put together in an interesting manner.

Some information on the subject is also contained in a prize essay on the Geology of Carnarvonshire, by Mr. G. E. Thomas, C.E., written in 1874.

None of these pamphlets are illustrated, and the four reprints of letters to the 'Mining Journal' are, I think, now out of print.

A practical and sensible paper on the working of the Festiniog Quarries, by Messrs. Langley and Bellamy, has also just been issued by the Institution of Civil Engineers.

As far as was practicable I have availed myself of the help afforded by these various pamphlets, and the references contained in larger works. My thanks are also due to my son, Mr. E. H. Davies, for his assistance in the preparation of the plans and sections by which the book is illustrated.

I trust that the book will do its part in helping to further remove what has grown into a great national industry out of the region of speculation and to place it on a sound scientific and commercial basis.

D. C. DAVIES.

EBNAL LODGE, OSWESTRY:
November 1877.

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SLATE AND SLATE QUARRYING.

CHAPTER I.

POSITION AND ORDER OF THE MATERIALS OF THE EARTH, ETC.

From the varied character of the surface of the earth, broken up as it is into sea and land, cliffs and gorges, valleys and mountains, ridges and peaks, we are able to examine the materials of which the earth is made, down to a depth of about fifteen miles. It has by this examination been ascertained that the rocks, generally known and described as strata, which compose this great thickness of material, lie on each other in a regular order, which is never, except by some local cause, reversed. These strata have further been divided into groups, which are distinguished from each other by the remains of former life that they contain, and which are more or less peculiar to each group. They are also distinguished by prevailing mineral characteristics. These groups of strata are now known by names *which have* for the most part been given to them by those explorers who paid special attention to them. The names are often derived from the towns near to which the groups of strata are best developed, and where they were originally studied. Thus the 'Llandeilo' group takes its name from the town of Llandeilo, in South Wales; the 'Bala' group from that of Bala, in North Wales; and the 'Wenlock' group from the little town of Wenlock, in Shropshire. Some of them are named after their distinguishing mineral characteristics, as the 'Carboniferous Limestone,' the 'Coal Formation,' and the 'Old' and the 'New Red Sandstones.' The annexed table affords a general view of the order and succession of these various groups; and a perusal of it, especially of the lower portion of it, will enable the reader to understand the position in the series occupied by the great slate-bearing deposits of the world.

To a greater or less extent slates and thin slabs, which have been used for the purposes of slates, are obtained from most of the foregoing strata; but the principal slate-producing rocks are those which lie below the 'Coal Formation.' In North Wales, which is by far the chief slate-producing country of the world, and to which most reference will be made in the following pages, the slates are obtained from the Cambrian, Lower and Upper, the Llandeilo, and the Wenlock strata, with possibly a few from the lower portion of the Bala group.

The general character of the strata comprising

Table of Strata.

CAINOZOIC OR TERTIARY		Recent		
		Post Pliocene		
		Newer Pliocene		
		Older Pliocene		
		Miocene		
		Eocene		Lower, Middle, and Upper
MESOZOIC OR SECONDARY		Cretaceous		Chalk Upper Greensand Gault Lower Greensand
		Wealden		Wealden Purbeck Beds
		Oolite	Upper	Portland Oolite Kimmeridge Clay
			Middle	Coral Rag Oxford Clay
			Lower	Cornbrash Forest Marble Bath or Great Oolite Stonesfield Slate Inferior Oolite
		Lias		Upper Lias Marlstone Lower Lias
		Trias		Rhætic Beds Keuper (New Red Marl) Bunter (New Red Sandstone)
PALÆOZOIC OR PRIMARY		Permian	Upper	Dark Red Sandstones and Marls
			Middle	Magnesian Limestones and Marls
			Lower	Conglomerates, Breccias, and Red Marls
		Carboniferous Series	Coal Formation	Upper Coal Measures Middle Coal Measures Lower Coal Measures
				Millstone Grit
			Carboniferous or Mountain Limestone	Limestone and Shales Carboniferous Limestone Calcareous Sandstone
		Devonian (Old Red Sandstone)	Devonian Beds	Upper Devonian Middle Devonian Lower Devonian
			Silurian, or Upper Silurian	Tilestones Upper Ludlow Beds Aymestry Limestone Lower Ludlow Beds Wenlock and Woolhope Limestone Denbigh Grits and Wenlock Shale Tarannon Shale Upper Llandovery
			Cambro, or Lower Silurian	Lower Llandovery Bala and Caradoc Beds Llandeilo Beds Arenig Beds
	Eozoic	Cambrian		Tremadoc Slates Lingula Flags Harlech and Llanberis Slates and Grits Longmynd Rocks
		Laurentian		Fundamental Gneiss of the North West of Scotland and Laurentian rocks of Canada

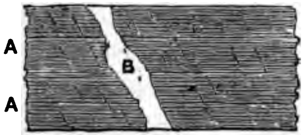
these slate-bearing groups may be described as beds of pebbles, sand, mud, and clay, each constituent prevailing in its turn. The beds were deposited in ages very far back, at the bottom of the sea, and in process of time they have been hardened into stone, and lifted up so as to form dry land. Between these beds, which we call sedimentary, there lie bands of harder matter, that vary very much in thickness. Some of these hard beds lead us to the inference that they have been ejected through cracks and openings in the strata below, as so much molten matter from fiery depths within the earth. These ancient cracks are now discernible in the shape of long dykes of greenstone and similar substances that fill up the original fissures; in bosses of the same materials, where the openings were limited and of irregular shape, and also in beds where the ejected materials were plentiful enough to flow far and wide over the strata previously deposited. These hard rocks have, as we shall see, had a good deal to do in the process by which the slate rocks have been brought into their present condition. It is the finer muddy portions of the sedimentary strata which, by a succession of chemical and mechanical processes, have become altered into slate. That these beds were originally deposited as so much mud in the sea we know, because, not to mention other reasons, they contain abundantly the remains of former sea-life, which lie along the planes of the bedding, and which even in slates, altered and cleaved, may be discerned in the bands and ridges by which they are crossed. It is not my purpose to describe these organic remains or fossils of the slate beds, but I may say generally that they belong to the lowly forms of sea-life. Zoophytes—corals and seaweeds; Mollusca—shell-fish; and Crustacea—crab-fish, shrimps, and lobsters; no traces of fishes having a backbone being found until we reach the beds above the Wenlock group. Those of my readers who would like to become acquainted with the fossils of these old strata may study Ramsay's 'Geology of North Wales,' Sedgwick and M'Coy's 'Palæozoic Rocks and Fossils,' and the 'Synopsis of Palæozoic Fossils,' in the Cambridge Museum. Taking the presence of these fossils in the strata we have to consider, as a proof that such strata were quietly deposited in an horizontal position, or nearly so, in ancient seas, we may from this point proceed to consider the inquiries—What were these old mud beds made of? How did they derive their colour? What were the peculiarities of their depositions, as these affect the slates they now yield? and what has been the process by which these ancient mud beds have been hardened into slate, and by which it has become possible to split them into thin plates in a direction quite different from that of their original bedding?

CHAPTER II.

MINERAL COMPOSITION OF SLATE ROCKS, ETC.

FROM what I have already said, it will be inferred that slate occurs in beds and not in veins, as is commonly supposed. Fig. 1 shows the difference between a vein and a bed, and slate beds succeed each other as the beds do in the diagram. When the word 'slate-vein' is used in this book, in accordance with popular custom it means a bed: perhaps a stricter use of the term 'vein' would be to use it only with reference to those portions of a slate bed in which the cleavage is most perfect.

FIG. 1.



A A *Beds.* B *Vein.*

There is a great variety in the materials of which a slate bed is composed. When flakes of mica enter largely into its composition it is called mica slate; when talc is present it is known as talcose slate; slate in which hornblende prevails is hornblende slate. These varieties, though used for various purposes, have not the commercial importance of clay slate, from which common variety of the material all the roofing slates of commerce are derived. The following analyses of five different kinds of slate will explain its ordinary composition. Its specific gravity is about twice that of water. For practical purposes it may be taken that one cubic foot of slate weighs 180 lbs.

The density of the material and its power of resisting pressure is very great. On an average it takes 20,000 lbs. weight to crush one cubic inch of slate. Its tenacity, and hence the power which thin plates of it have of sustaining great weights, is also very great; the pre-eminence in this respect being accorded to the ordinary slates of North Wales.

1. *Analysis of greyish-black slate from Bondorf, given by Dr. Bischoff:—*

Silica	62·59
Alumina	16.88
Protoxide of iron	8·42
Lime	0·24
Magnesia	2·26
Potash	3·31
Oxide of copper	0·13
Carbonate of lime	1·22
Water	4·03
Carbon and loss	0·92
	100·00

Dr. Bischoff found that there were but slight differences between the results of thirty-six analyses made

2. *Analysis of ordinary Welsh roofing slate (blue), given by Professor Hull*[1]:—

Silica	60·50
Alumina	19·70
Iron (protoxide)	7·83
Lime	1·12
Magnesia	2·20
Potash	3·18
Soda	2·20
Water	3·30
	100·03

3. *Analysis of dark blue slate from Llangynog, North Wales, b Mr. D. H. Richards, Analytical Chemist of Oswestry. Analysi of slate dried at* 100 *C.* :—

Loss on ignition	3·720
Silica	60·150
Protoxide of iron	5·837
Sesquioxide of iron	1·815
Alumina	24·200
Not determined—Alkalies, &c.	4·278
	100·000

4. *Analysis of the material of the green bands in the bluish-purple slates of Llanberis, made at the Royal School of Mines for Mr. George Maw, F.G.S., of Broseley*[2]:—

Silica	66·45
Titanic acid	0·63
Alumina	13·38
Protoxide of iron	1·71
Peroxide of iron	1·41
Protosesquioxide of manganese	0·91
Lime	2·86
Magnesia	6·28
Potash	0·05
Soda	0·90
Carbonic acid	1·30
Combined water	3·90
Hygroscopic water	0·13
	99·91

---

[1] *Building-stones of Great Britain.*

[2] *Geological Magazine*, 1868, p. 123.

In examining the same material under a microscope, the late Mr. David Forbes found a small quantity of a greenish mineral, probably chlorite.

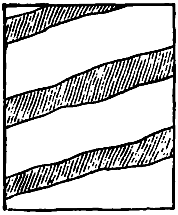
5. *Analysis of the purple slates of Nantlle, given in Kirwan's 'Mineralogy,' vol. I., p.* 236 :—

Silica	48
Argillaceous matter	26
Magnesia	8
Lime	4
Iron	14
	100

These analyses will be sufficient to show that the bulk of a slate deposit is made up chiefly of silica and alumina, and was therefore at one time ordinary clay. The colour of the deposit at any given place depends upon the quantity and nature of the mineral matter which we see in smaller quantities is mixed up with it. The ordinary colour of roofing slates is blue of different shades. This colour is derived from the presence of protoxide of iron, or iron and oxygen mixed in the proportion of two parts of the former to two of the latter. The red and purple varieties take their colour, like the marls of the Permian strata, from iron in the form of peroxide —two parts of iron combined with three of oxygen. Into slates of a green colour, which is the least common variety, iron less largely enters, and in combination with magnesia, gives them their greenish hue. In soft black slates there is a good deal of carbonaceous matter, and sulphide of iron, in a decomposed state, finely disseminated throughout the mass.

Frequently slates have a riband-like appearance, bands of a different coloured material crossing the slate, as in fig. 2.

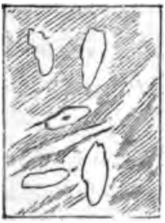
FIG. 2.



Striped or Banded Slate.

In this case we see how, at successive times, the deposit has been tinged with different coloured pigments. The same result would be attained if at a coal-pit we were to take first, a lump of the reddish-yellow boulder-clay and flatten it out upon a table, then lay a lump of blue upon it, and upon this a lump of red, and cover this again with a lump of pale fire-clay, then press them all closely together, when, if we were to cut the whole series through, there would be coloured bands of the various clays. Occasionally, and especially among the Cambrian slates of Carnarvonshire, we find slates blue, green, and purple, in which there are oval, round, and irregular patches of white or pale yellow (fig. 3). In these we have little lumps of the original material, from which all colouring matter is absent, just as in the purple clay beds of the Permian strata we now find small concretions of perfectly white clay, into which the coloured matter has not penetrated.

FIG. 3.



Spotted Slate.

When the materials of which these ancient deposits were formed were washed from the older lands, whence they were derived, and carried down to the sea by streams and rivers, they would be subject first of all to a sorting process. The heavy coarse materials would be deposited first near to the shore; the finer matter would be carried further out to sea, and spreading itself over a large area, would be quietly precipitated to the bottom in deeper water. The lightest portions of all would be held longest in solution, and would reach the furthest from the shore line. The even deposition of the whole of these materials would be affected by oceanic and tidal currents, as well as by storms then, as now, more or less periodical. We might therefore naturally expect to find, even in the finest deposit, layers of coarser material—the result of such storms. Storms sweeping over the land and flooding the rivers would also affect the deposit. The colour would be influenced by the presence and decomposition of any mineral ores over which such waters flowed. All this is true of similar deposits through all time. I may refer again to the marls of the Permian age. In sinking coal-pits through such marls we find all the variations of colour referred to. Thin beds of green, grey, blue, and purple marls. Massive beds of each colour, and mottled beds, answering to the spotted slates, together with all the variations in the size of the material. We see the same thing in the muddy layers at the bottom of a pool or lake which has been drained dry; and we have only to imagine such deposits consolidated, compressed, and cleaved, to make them into all the varieties of slates I have described.

A consideration of these simple laws of deposition will help us to understand that, in a slate-bed that extends over miles of country, we should naturally expect many variations in its colour, its consistency, and its thickness. It may be fine and smooth here where the fine mud has fallen, and rough there where the coarser stuff has been thrown down. It may be speckled with iron pyrites, or stained black with carbon here, where formerly sea vegetation flourished, and be quite free there where the sea bottom was below the line where such forms of life grow. It may be coloured purple in a particular locality, or a particular bed may have taken that colour where and when the water was tinged with peroxide of iron; or blue, as the protoxide prevailed, as for the most part it did; or green, as the protoxide was influenced by magnesia. The presence of soda and potash in all the slate deposits is the record of the saltness of these ancient seas. It will be seen, therefore, that it is fallacious to suppose that, because a slate rock is proved to be good or bad in a particular quarry, it must maintain the same character throughout its entire course. Each particular portion of the range of a slate bed must answer for itself.

CHAPTER III.

ON SLATY CLEAVAGE.

EVEN where a slate is of one colour, lines sometimes wavy but oftener straight are seen crossing it, and the slate must be a very perfect one on which all traces of these lines have been obliterated. It will be inferred that if these lines and the different coloured layers are the lines of original bedding as they are, the lines along which slates usually split must be something different; and this is so. The direction of these lines of cleavage coincides with the strike of the beds, or the direction which the latter take across the country; and it is, consequently, at right angles to the dip or inclination of the strata. Thus the direction of the cleavage in North Wales corresponds to the NE. and SW. lines on the map, and which show the outcrops of the slate beds along the great slate ranges of the Principality. By a reference to the general section, fig. 12, it will be seen that the dip of the slate beds is now to the NW. and then to the SE., but always at right angles to the direction taken by the lines of cleavage.

Cleavage occurs at almost all angles of inclination from the planes of bedding. Fig. 4 is an actual representation of a quarry in Carnarvonshire. The undulating lines are the lines of bedding; the nearly vertical lines are those of the cleavage. Owing to the curvings of the former, the lines of cleavage sometimes nearly coincide with them, and cross them at all angles up to ninety degrees.

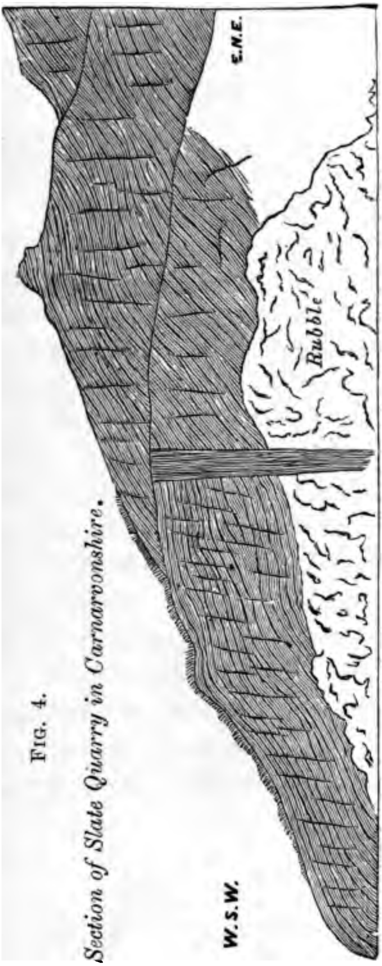


Fig. 4.

Section of Slate Quarry in Carnarvonshire.

Lines of cleavage were formerly often mistaken for lines of bedding, and serious mistakes as to the relative position of great rock masses were made as a consequence. Mr. Bakewell, in his 'Introduction to Geology,' published in the year

1815, seems to have first pointed out the distinction, when he says, 'The slaty and tabular structure are, I conceive, the effects of crystallisation, depending on the nature of its constituent parts.' In the year 1835, the late Professor Sedgwick treated the question very philosophically in his 'Chemical Changes produced in the Aggregation of Stratified Rocks during different Periods of their Deposition.'[1]

There is some difference of opinion among those who have given attention to the subject, as to the precise manner in which the phenomenon of slaty cleavage has been produced. Professor Sedgwick describes it as a new crystalline arrangement, like the laminæ in a piece of spar, producing a regular cleavage more or less inclined to the original beds. He had seen the artificial production of cleavage by passing magnetic currents through soft masses of clay, and he concluded that slaty cleavage had been produced by a similar force. His words are, 'In the Welsh slate rocks we see cleavage planes pass through contorted strata of hard slate, obviously of sedimentary origin. . . . Crystalline forces have rearranged whole mountain masses, producing a beautiful crystalline cleavage, passing alike through all the strata. . . . They—the cleavage lines—appear to be only resolvable on the supposition that crystalline or polar forces acted on the whole mass, and with adequate power.'[2]

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[1] *Trans. Geol. Society*, N.S. vol. iii.

[2] *Geology of the Lake District*, p. 196.

So Sir H. De la Beche, writing in 1839, says, 'When we ... consider the mineral modifications which the sedimentary beds have generally undergone since they were deposited, we are led to suspect not only that the lamination planes, commonly termed cleavage, are, as has been considered probable by some authors, due to *polar force*, but also that the great divisional planes have been equally caused by them.'[1] It is also pointed out by writers who have adopted this view, that the direction of the cleavage (see lines on map) being uniformly NNE. not only in Wales, but also elsewhere, coincides with the course formerly taken by the magnetic currents which are ever passing northward through the earth. On the other hand, we find the late Professor Phillips assuming cleavage to be due to mechanical forces that compressed the sediment at right angles to the direction of the cleavage. Mr. Sorby, who studied the subject microscopically, and otherwise very minutely, was also led to the conclusion that cleavage is the result of pressure, by which the sediment has been compressed to about one-half its original bulk, and the particles pressed with their flattest sides towards each other. The reader may see this arrangement himself, if he will grind a piece of ordinary slate very thin, so as to admit light through it, and place it under a good microscope. Mr. Poulett Scrope took the same view; so also does Professor Tyndall, who illustrates the process in the course of his lectures by an experiment. He takes a piece of well-kneaded fine white wax, which of course is one mass, without any divisional lines in it. This is pressed and worked together between two pieces of wet glass, when the wax becomes rearranged, and is easily separable into plates with flaky sides, just like a piece of newly-split slate rock. The same process is performed daily by housewives in the rolling of pastry between the rolling-pin and the board. Professor Ramsay, who of all men has had the most abundant opportunities of studying the structure of the Welsh slate rocks, follows on the same side. The bulk of opinion therefore, and, as I think, the weight of evidence, seems to be in favour of the *mechanical* theory of the origin of slaty cleavage. It is nevertheless true that the same result has in experiments been obtained by the influence of magnetic currents, so that we may readily conclude that the total result was facilitated by the previous long-continued action of chemical and magnetic forces. When we turn to actual facts, and see what has really taken place, we find in the structure of North Wales evidence that the two sets of forces have been concurrent in the direction of their agency.

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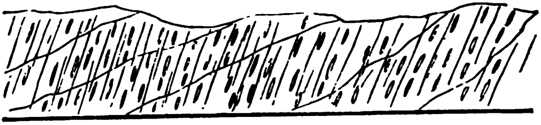
[1] *Geological Report of Cornwall and Devon.*

Supposing the magnetic currents which formerly moved towards the east of north had a tendency to mould the sedimentary strata so that they would split easily in that direction, it will also be seen by a reference to the map and to the general section fig. 12, that the great crumpling and rolling the strata have undergone, by means of forces acting on the WNW. and ESE. would produce the result of slaty cleavage at right angles to these forces—acting as rolling-pin and board—making the strata flaky and cleavable in the same direction—NNE.—of the magnetic currents.

How mighty those forces were and how great the crumpling the strata have undergone, either by sudden or slowly operating causes, will be understood by the great undulations of the strata, as shown in the general section, in which the minor contortions are of necessity omitted.

FIG. 5.



The effect of slaty cleavage is as distinct and persistent as the causes producing it were powerful. Thus we see it affecting all substances within its reach. Even compact limestones are occasionally affected by it to some extent: and at page 145 of his 'Memoir on the Geology of North Wales,' Professor Ramsay gives a notable instance of the way in which the pebbles of a Cambrian conglomerate (fig. 5), near Llanberis, are all flattened and elongated by it, and rearranged with their flat sides towards each other.

The simple story then, briefly told, is this. There was first of all an immense quantity of mud washed by rains of the old lands and carried by rivers to the seas

This mud was made up, for the most part, of silica and felspar, with smaller amounts of lime, magnesia, iron, potash, copper, and carbon. When brought to the sea the mud was deposited in layers or beds, in which the remains of creatures belonging to the sea became imbedded. The mud, in course of time, got covered with other materials. The whole mass slowly hardened and consolidated by pressure as well as by heat. Lifted up out of the water, it cracked and split in various directions in the process of drying. Influenced by that law of crystallisation by which all minerals assume certain definite shapes, silica and felspar forming the bulk of the deposit, the mass split up, for the most part, into rough rhomboidal masses. This crystallisation and splitting was aided, during long ages, by magnetic currents, which passed through the mass to the NNE., and which gave a tendency in the particles to arrange themselves in that direction. Then there came great disturbing forces, by which the beds were bent and twisted in all directions. The great pressure attendant on these lay, as we have seen, between the WNW. and ESE. Between these two points the particles of the mass became flattened and compressed into about half their original bulk, and thus was imparted to the unbroken masses of rock that lay between the great cracks and divisional planes that tendency to peel off from each other which we now know by the name of slaty cleavage.

CHAPTER IV.

ON CAUSES AFFECTING SLATY CLEAVAGE, ETC.

Perfect cleavage.—Having noticed the means by which the phenomenon of slaty cleavage has been produced, let us next take into consideration several circumstances by which the condition of that cleavage would be affected. As a matter of fact we find that the cleavage is most perfect, straight, thin, and uniform where the materials are fine and of uniform nature and consistency. When this was the case there was nothing to hinder the uniformity of the pressure over the entire mass.

Posts.—Between such beds, however, we often find one or more of a different texture, fine perhaps, but hard and compact, the materials so closely cemented together that the bed is but little affected by cleavage. This is known in quarrying as a post. Such hard beds have, however, had their uses, and their occurrence in a slate bed of considerable thickness is not altogether to be deplored. It seems to have been essential to the production of good cleavage that, as shown in fig. 6, *there should* not only be pressure laterally between the points A A to produce cleavage in the slate bed 2, but also that there should be at no great distance from each other hard beds 1 1 to keep the softer slate deposit from escaping from the force of that pressure. The quarrymen seem to be aware of this, hence the saying, 'without posts no slate.' There are posts of another kind. Sometimes heat from the interior of the earth has found its way up a crack and baked the surrounding slate rock, sometimes to the extent of converting it into steatite or porcellanite, and often so destroying the cleavage as to render slate-making impossible. Sometimes a mass of shattered rock is called a post, but this is a misnomer.

FIG. 6.

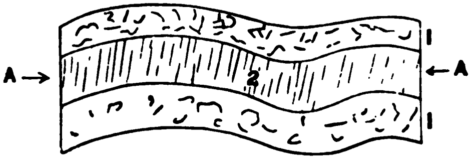
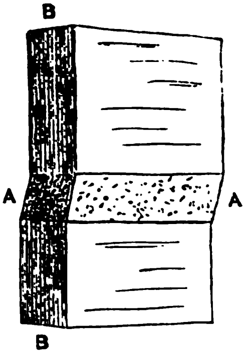


FIG. 7.

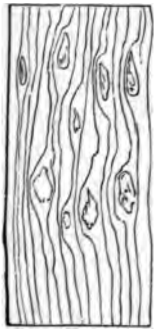


Bends.—It will be readily inferred that where there are changes in the texture, size, and quality of the materials of a slate deposit, there will be consequent alterations in the character of the cleavage. A layer of coarse matter has bent the line of cleavage, as a ray of light is bent when it enters the denser material of water. Fig. 7 is an example of this, and represents a slate block, across which at A A there is a band of coarser material. The result of the occurrence of this band is, that as the block is split from B to B, each slate is bent at A A, and is either worthless, or fit only for third or second quality.

Cramps.—Again if the band A A be of a more compact nature than the rest of the mass, say having a larger admixture of lime, felspar, or other cementing matter, the result will be what is known as a 'cramp,' and the slates will have a tendency to break off on either side of it.

Crychs or Curls.—Sometimes the band A A occurs in the form of a roll or curl, when the practical result is rather worse than in either of the former cases. When a portion of a slate bed is very curly the working of it may be rendered unprofitable. In accounting for these rolls, it is easy for us to imagine how in a sea deposit there would here and there be ripple, wave, and current lines, into which matter would be floated different from the rest of the deposit, just as we now see similar indentations in a muddy beach filled with blown sand or softer matter ready to be covered by the next tide. Of a similar nature, but producing bends and contortions on a larger scale, are the large masses of concretionary

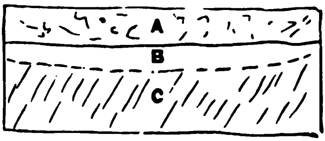
FIG. 8.



matter which are sometimes found in a slate bed. By their greater hardness they have bent the lines of cleavage into a series of rolls or curves. Fig. 8 is an illustration of this.

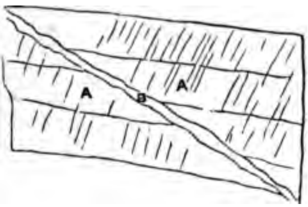
Hardened strata.—When a slate bed is overlaid by a deposit of felspathic, porphyritic, or ashy matter, which seems to have flown over it in a molten state, the upper surface of the bed, especially in those portions where the heat has been most intense, is metamorphosed, altered into a hard and unworkable condition for slates, as at B; in fig. 9, A is the overlying hard rock, B is the changed portion of C, the slate bed. We shall have to notice several examples of this as we proceed.

FIG. 9.



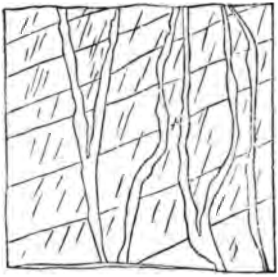
Dykes.—The same thing is often true of slate rock in the vicinity of dykes, of greenstone, or other igneous or eruptive rocks, such as may be seen in most quarries. Fig. 10 shows such a dyke B, traversing the slate beds A A, and in all probability the rock contiguous to its course will be rendered unworkable.

FIG. 10.



Sparry veins.—In most slate quarries may be seen a cluster of white veins, which, springing from the bottom of the quarry, often ramify, before they reach the top, into a considerable network of veins, fig. 11. These veins are usually filled with white quartz, and are known as sparry veins. They cut the slate rock in their vicinity into fragments, and besides this the neighbouring rock is often hardened, and the cleavage destroyed. This hardening does not seem to result so much from the presence of the quartz or other mineral matter in the veins, as from heat evolved through these cracks prior to the time when they became filled by infiltration or otherwise with extraneous matter.

FIG. 11.



Wavy cleavage.—Since the period when cleavage was produced, the strata seem to have been subjected to many disturbing causes, from some of which they have been bent into rolls and curves, and thus the cleavage lines which originally were straight are also bent, and the rock rendered comparatively worthless for commercial purposes.

Joints.—Besides the original cracks and divisional lines resulting from drying and crystallisation, the strata, in the neighbourhood of great faults especially, are often much shattered, and broken up so small as to render it impossible to obtain slates of sufficient size.

Double cleavage.—The original cleavage of the older rocks of North Wales, which, as we have seen, runs SSW. to NNE. has at some subsequent period been followed by causes which, operating in other directions, have in certain districts produced a cleavage that crosses the original one. The effect of this where the force has been most intense has been to cut the rock up into slate pencil, and in localities more remote from the centre of the force to cause the slates to split down the middle. It follows from the foregoing considerations that in every slate quarry there is a large amount of unprofitable rock. We have, however, to add top-rock, which, exposed for ages to the action of the sea, rain, frost, and atmosphere, is broken up and otherwise altered for the worse, and has to be removed to the depth of from six to twenty yards before the rock is found in its normal state. A large amount of waste is also inevitable in the working of a quarry. The proportion of finished slates to the entire mass of rock varies: one ton of slates out of twelve tons of rock is a good proportion, one ton out of sixteen or twenty is of frequent occurrence, and I have an example before me of a good paying quarry, where one hundred tons of rock have to be removed for every three and a half tons of slates made, or one in thirty-three and a third tons.

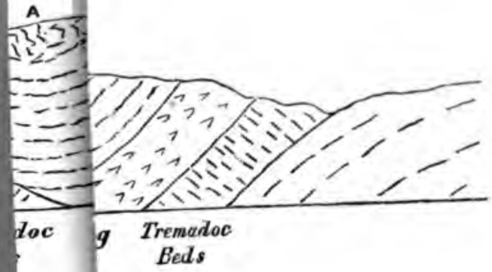
CHAPTER V.

SLATE BEDS OF THE LOWER CAMBRIAN ST OF NORTH WALES.

In proceeding to describe in detail the various g of slate-yielding rocks in North Wales, I would explain the relation sustained to each other by th line map (*frontispiece*), and the diagram section, fi The lines on the map represent the leading slate r of North Wales. Each line is numbered, and a sponding number is placed on the general section about the point where the line crosses it, or would it if it were prolonged far enough. All fault minor details are purposely omitted from this se in order that the attention of the reader may n diverted from the main purposes intended to be s by it, and which are, first, to show the general geol structure of North Wales, and, secondly, to giv main divisions of the successive strata. The d will be given as far as is practicable in sections trative of each slate range.

Slate range of line 1.—Beginning at the left or western end of the section, I will commence w

AGRA


A
doc
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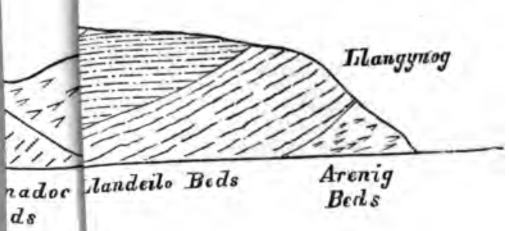

Llangynog
nadoc
ds
Llandeilo Beds
Arenig Beds

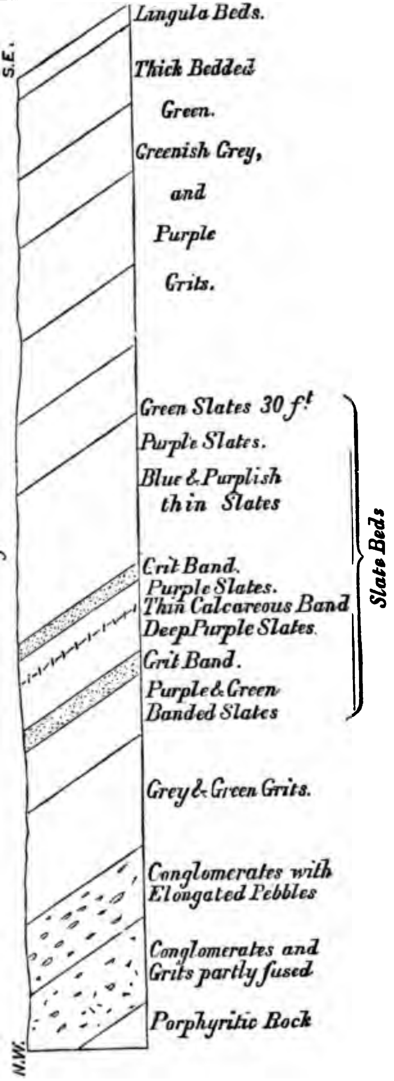
description of the slate beds of the Lower Cambrian rocks of Carnarvonshire. These rocks are the lowest, and therefore the oldest, rocks in North Wales. The name was given to them by the late Professor Sedgwick after the country itself, because of their great development in the principality. In Carnarvonshire their thickness is estimated at about 3,000 feet. It will be observed that they rise to the surface again in the middle of the section in Merionethshire. From this point they again dip underground, but they come to the surface again in Shropshire in the Longmynd hills, where their thickness cannot be much less than 25,000 feet. Fig. 13 is a general section of these strata in Carnarvonshire in the neighbourhood of Llanberis, and a perusal of it will help the reader to understand how the 3,000 feet of strata are made up.

It will be seen that at the base of the section there is a great mass of porphyritic rock, which passes upwards into a conglomerate, in which the outlines of the enclosed pebbles are partly obliterated by heat. This is followed by the conglomerate before referred to, in which the pebbles are elongated and flattened by slaty cleavage. This conglomerate is surmounted by a succession of grey and green grits that form the summit of this lowest division of the group, the combined thickness of which is about 1,000 feet. It is the middle division that contains the great slate deposits. Above the grits just described we reach a series of green and purple banded slates. These are divided by a band of

FIG. 13.

General section of the Cambrian strata in Carnarvonshire.

500 ft.— 1 inch

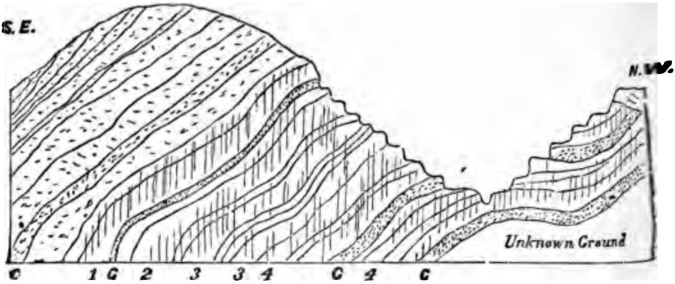


grits from a deposit of deep purple slates. A very thin band of sandy limestone separates this from a series of slate beds of a purplish colour. Another grit band succeeds, and then comes the principal deposit of blue and bluish-purple slates. Purple slates again succeed, and the whole series is capped by a band of green slate that ranges from 20 to 30 feet in thickness.

The entire thickness of this Cambrian slate group is about 900 feet, but the thickness of the whole series and that of individual beds varies in different localities. This slate division is followed by a succession of grey, green, and purplish grits of an aggregate thickness of 1,100 feet, and which, where they are not disturbed by faults, dip under the Lingula flags of the Upper Cambrian. It may be remarked of the slates of this group and range generally, that they are hard, and have a sharp metallic ring. The hardness is said to increase towards the southern extremity of the line. The area comprised in this range is about fourteen miles long, extending from a point between Bangor and Aber on the NE. to Llanllyfni on the SW. where the beds are lost under low ground. It is about five miles wide midway along this length, and it narrows in width as either extremity is reached. The quarries are situated for the most part along the edges of the area, the central portion of which is occupied by the underlying porphyry, which is thrown up through the mass of the overlying beds. The two largest quarries of the range, as well as of North Wales, are the Penrhyn, situated about five miles SE. of Bangor, and the Dinorwig, which are worked close to the village of Llanberis. Apart from their size and commercial importance, these quarries demand special mention because in them the whole series of the slate beds is worked. Fig. 14 is a section across the Penrhyn quarries, which shows the same general order of beds as we have in fig. 13.

FIG. 14.

Section of the Penrhyn Slate Quarries.



G G G G are the dividing grit bands; 1 is the bed of green slates that lies at the summit of the series; 2 are the purple slates; 3 3 the great mass of blue and purplish-blue slates; and 4 4 the purple and red slates that lie at the base of the series. These groups of slate rocks are further divided locally as follows:—

LLANBERIS.	NANTLLE.
Group 1.—Green Slates.	
Green vein	Green vein
Group 2.—Purple Slates.	
Goch galed, or silky red vein	Silky vein
Glas galed, or hard spotted blue vein	Blue mottled vein

Group 3.—Blue Slates.

las Rhiwiog, royal blue vein
och Grychlyd, or curly red vein
en las, or old blue vein
och galed, red hard vein
lynrhonwy vein

Red and blue striped vein
Red spotted vein
Purple vein
Purple striped vein
Faen goch, or red vein

Of these beds the slates from the green vein com-
and the highest price, but the sale is limited, and the
ed is not much worked in the great quarries. It is
imited also in thickness; but at Goodman's Quarry,
W. of Llanberis, it attains the exceptional thickness of
20 feet. In the southern part of the area the silky vein
ives slates of a beautiful rosy tint, but they are often
oo soft for marketable purposes. The Glas galed and
he Glas Rhiwiog are beds largely worked, the blue slates
f the latter being the most in request. At Penrhyn
he Glas Rhiwiog is the richest worked. It loses its
lue colour as it is worked in depth. The Glas galed is
ardly adapted, from its hardness, for best slates. In
he southern district even the blue beds have a purplish
inge. The next three are worked in most of the quar-
ies. At the Dinorwig quarries they are very hard,
nd often difficult to work, but when made into slates
nd fixed they are exceedingly durable. The Goch
aled is less red as it is followed in depth. The Faen
och, or red vein, is not much worked at Penrhyn and
inorwig, but it becomes a valuable bed further south.
t Cilgwyn it is about sixty yards thick, and it seems
o increase in thickness downwards. At most of the
uarries on the eastern side of the area there is a great

NAMES AND PARTICULARS OF QUARRIES

LINE I OF MAP

Name	Situation	Name of the Proprietor or Company	Date of origi
Alexandra	Moel Tryfaen .	Private Company .	1860
Bettws Garmon . .	Bettws Garmon .	....	....
Braich	Cilgwyn Mountain, Nantlle .	Private Company .	1830
Brynhafodywern .	Bethesda . . .	Bangor Slate Company (Limited) .	Very old; resuscitated in 18
Bryn Mawr	Bettws Garmon .	....	....
Cambrian	Llanberis, SW. .	Cambrian Slate Quarries Company (Limited)	....
Carnarvon and Bangor	Nantlle	....	....
Cefn Du	Llanberis, SW. .	....	....
Cilgwyn	Nantlle	Hayward & Co. . .	12th century; resuscitated 1880; present do. 1849
Cloddfarcoed . . .	Do.	....	1790; recently revived
Cook and Ddol . .	Llanberis, SW. .	Trew Iegon	No date for old workings; recently revived
Coed Madoc	Nantlle	....	....
Dinorwig	Llanberis, NE. .	G. W. D. Assheton Smith	1750
Dorothea	Nantlle, NE. . .	Williams & Co. . .	1820
Ffron	Do.	Talysarn Slate Company (Limited) .	1830 Revived 1860
Ffronheulog . . .	Nantlle, S. . .	Turner & Company (Limited)	1840 Revived 1866
Gallt-y-Fedw . . .	Nantlle	Williams & Co. . .	No date for old workings; recently revived
Glynrhonwy Lower .	Llanberis, W. .	....	Do.
Glynrhonwy Upper .	Do.	....	Do.
Goodmans	Do.	Private Company . .	Do.
Gwernor	Nantlle, SW. . .	....	....
Moel Tryfaen Quarry	Moel Tryfaen .	....	....
Pant-Dreiniog . . .	Bethesda . . .	Bangor and Pant-Dreiniog Slate Co. (Limited) . .	1805 Present Company 1873
Penrhyn	Do.	Lord Penrhyn . . .	1600
Penybryn	Nantlle	....	1770; present Company 18
Pen-yr Orsedd . . .	Do.	....	....
South Dorothea . .	Do.	....	....
Tanyrallt	Nantlle, S. . .	....	1805 Revived 1863
Tanybwlch	Bethesda . . .	Port Bangor Slate Company (Limited)	....
Treblaen	Bettws Garmon .	....	....
Tyddyn Agnes and Ty-n-Llwyn . . .	Nantlle, S. . .	....	....
Ty-Mawr	Do.	....	....
Y-Foel	Moel Tryfaen .	Pearson & Co. . . .	1880; present Company 1

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* I give the figures in this column as they are quoted by the writer of the
quantities, especially from the larger

WER CAMBRIAN STRATA, NORTH WALES.

SECTION.

l or vein of slate worked, with remarks	No. of men said to be employed in 1873	Estimated No. of tons raised in 1872*	Approximate value
or red and red spotted vein .			
.... ; few joints	140	6,000	£15,000
mottled blue; green slates of ; quality	20		
.... urple spotted, joints frequent .	120	5,000	18,000
.... :ped and red; good quality . .	50	1,500	3.500
ple, and red spotted; red vein 60 yards wide, and thickens rds	260	6,000	25,000
. . . .	4		
urple	40	1,000	2,500
.... ns	3,000	150,000	300,000
l red veins; few foot joints . .	500	10,000	25,000
e, striped purple and red . . .	70	1,000	2,500
striped blue	80	1,500	3,500
....	12		
le, and red	200	8,000	16,000
do.	40	1,000	25,000
do.	20		
. . . .	20	1,000	2,500
.... le and red	50	1,500	3,500
ds or veins . . . . d blue; a bed of green slates in st of the others	3,500	250,000	560,000
....			
....			
....			
....	40	1,000	2,500
led	20		
....			
....	20		
....	20	1,000	2,500

Resources of Carnarvonshire. I have a strong conviction however, that the
See tables at the end of Chapter XXII.

absence of joints, so much so as to render the quarrying of the beds somewhat difficult. Slabs of a very large size, up to nine yards in length, may be obtained, and some of the harder beds are more suitable for the manufacture of slabs than slates. In the quarries SW. of Llanberis, on the other hand, joints are of rather too frequent occurrence, the rock being shattered somewhat from its nearness to large faults. Partly on this account the quarries in this portion of the area have scarcely attained the dimensions and success of some of the others. Besides the hard grit bands that divide the slate beds, dykes of felspar, greenstone, and other eruptive rocks, traverse most of the quarries throughout the whole area. These run irregularly through and across the slate beds, as shown in fig. 10.

The foregoing is a list, with particulars as far as obtainable, of the various quarries as they were worked in 1873. It is to be regretted that statistics of slate quarries are not included in the yearly volume of Mineral Statistics compiled by Mr. Robert Hunt, and published by the Geological Survey. As it is, the foregoing is the latest and fullest account I am able to give, and doubtless, at the present time, other quarries could be added which were not in work in 1873.

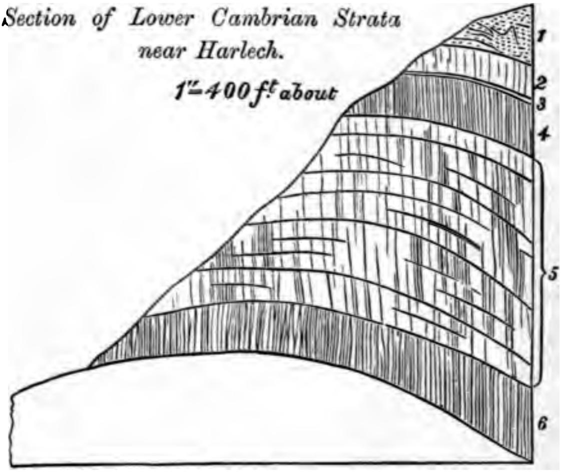
CHAPTER VI.

LOWER CAMBRIAN STRATA OF MERIONETHSHIRE —SLATES OF THE LINGULA FLAGS, AND TREMADOC SLATES, UPPER CAMBRIAN, AND OF THE ARENIG GROUP.

Before leaving the slates of the Cambrian strata I must notice the development of the latter in Merionethshire, line I A of map and general section. These rocks form what is known among geologists as the Merionethshire anticlinal, from the centre of which, as is shown in the diagram section, the various overlying beds dip in opposite directions. Although the Cambrian strata have increased in their underground course from Carnarvonshire to more than double their thickness in that county, it appears that the increase is by the addition of grits and conglomerates to the upper division of the strata. Where the lower beds come to the surface, the slates appear in their true position, and various small attempts have been made to work them in the valleys and on the coast near Harlech. In the centre of the anticlinal, near Rhinogfawr, slate beds are seen rising from underneath the great mass of the grits. For the most part the slates are covered, and much of the ground lies low. The thickness of these slate beds could, however, be ascertained by boring. Any future quarrying operations in this part of the district will have to be conducted, as shown in fig. 31, by shafts and underground workings, as in ordinary coal mines.

The following section, fig. 14A, affords a good view of the order of the slate beds near Harlech, on the

FIG. 14A.



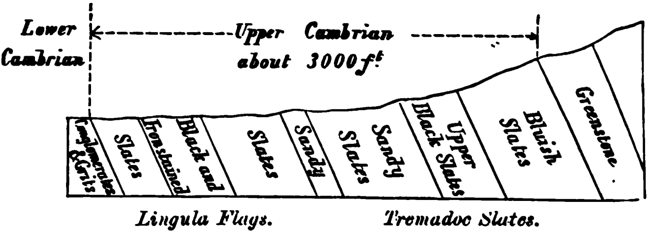
1. *Harlech Grit.*
2. *Green Slates.*
3. *Thin Hard Rock.*
4. *Blue Slates.*
5. *Bluish Purple Slates. Interstratified with hard Bands of Rocks.*
6. *Purple Slates.*

SW. It is interesting also as showing the close resemblance of the order and character of the slate beds at this point to those of Carnarvonshire. Ordinary en and chambered quarries would be practicable in s part of the range.

Slate Beds of the Lingula Flags and Tremadoc ates, Upper Cambrian.—These strata are usually ssed with the great Silurian system of rocks. They ere, however, originally described as Cambrian by the te Professor Sedgwick, the first expositor of these old rata. There is now a strong tendency on the part of ologists to revert to the original classification, and adopt it in this book as being more true to nature, d as one more congenial to my feelings of regard to e eminent geologist by whom they were first exined. These strata are best developed in the neighurhood of Tremadoc and Portmadoc. The lower rtion of them take their name from the little bi lve shell Lingula or Lingulella, which they contain undantly. These are surmounted by the slates and ales which underlie the great mass of rock that overngs the little town of Tremadoc. The two divisions ay, for the practical purposes of this volume, be ouped into one. The series is about 2,000 feet ick in Carnarvonshire, but, like the lower strata, it ickens eastward, so that as it is developed around e Lower Cambrian beds of Carnarvonshire, it reaches thickness of 5,000 feet. As shown in fig. 15 they nsist in the lower part of black slates, which are cceeded by a great thickness of grey sandy slates, hich form the principal division of the series. These ey slates are surmounted by a band of black slates.

This is succeeded by a series of fine-grained slates of a bluish colour. Attempts at slate quarrying in this group have, with a solitary exception, been unsuccessful. The cause of this failure is twofold. First, nearly the whole series is largely stained with iron; and, secondly, the stratification embraces a variety of materials, and, as a consequence, the cleavage is irregular and uncertain. The exception to these failures is the Arthog Quarry, on the south side of the Barmouth estuary, line 2 of map and section. The slates are not fine or quite free from pyrites, but they are marketable. It is probable that this quarry is worked in the Tremadoc slates, which lie near the top of the group, and consequently are higher in the series than those of the quarries nearer the sea. It is possible that future explorations around the Merionethshire anticlinal may reveal more promising localities, especially in the blue slates near the summit of the group. The quantity of slates sent by rail from these quarries last year was 669 tons. Including those sent by water, we may estimate the entire produce at 1,500 tons.

FIG. 15.



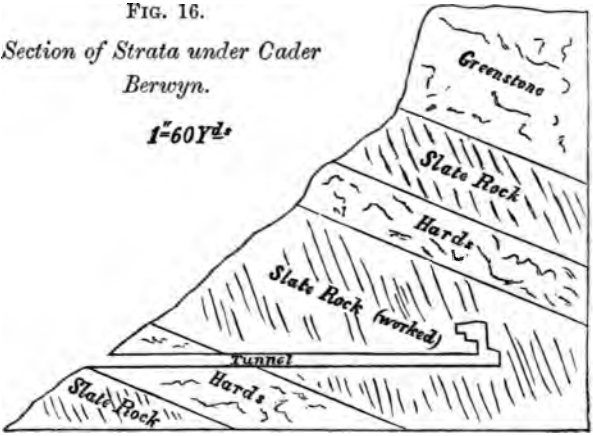
Slates of the Arenig Strata.—Resting upon the Tremadoc slates we find a thick zone of strata, which were originally described by the late Professor Sedgwick as the 'Arenig group.' The name is taken from the Arenig mountains, about twelve miles west of the town of Bala, N. Wales. Subsequently for a time, and while but little understood, they were classed with the Lower Llandeilo beds, described by the late Sir R. I. Murchison. Latterly much attention has been given to them, and, as in the case of the beds last described, there is a strong tendency to revert to the old name. For the reasons before given I use it now. The group in its natural position rests immediately upon the Tremadoc slates, but there is evidently a wide gap in time between the two groups. As far as at present known, only one of the many fossils which are found in the Lingula flags and Tremadoc slates is found as well in the Arenig beds. Lists of the fossils of the two groups may be found in Ramsay's 'Geology of North Wales,' and in the 'Catalogue of Cambrian and Silurian Fossils,' published by the University of Cambridge. The strata have usually a dark colour; they are comparatively free in the lower part from eruptive rocks, as well as from interbedded lavas. These, however, do appear towards the summit of the series. The Crown Slate Quarry, near Dolgelly, a little to the east of the centre of line 2 of map, is worked in this series. So also is the Maengwynedd Quarry, near Cader Berwyn, a little to the east of the NE. end of line 3 E of map. Fig. 16

is a section of the strata, as proved at the latter quarry, and it may be taken as a fair representation of the upper portion of the beds.

FIG. 16.

Section of Strata under Cader Berwyn.

1"=60Yd.



Pyrites are of common occurrence in the strata about Dolgelly. Under Cader Berwyn, the beds are comparatively free from them. The slates here are of a dark blue colour, smooth, and possess a good cleavage. They are softer than the Carnarvonshire slates, and than most of those worked in Merionethshire, between which and those of the Wenlock beds they seem to hold a middle place. The quantity of slates sent from Dolgelly last year from quarries worked in these beds was 1,506 tons; with local sales the production may be taken at 1,750 tons.

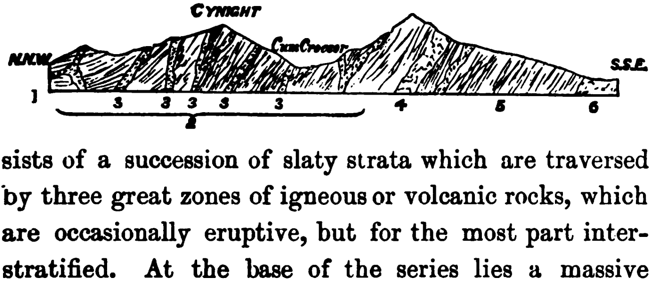
CHAPTER VII.

SLATES OF THE LLANDEILO STRATA.

We now approach the consideration of a group of slate rocks which in importance are not surpassed by those of the Lower Cambrian strata of Carnarvonshire. By a reference to fig. 17 it will be seen that the group consists of a succession of slaty strata which are traversed by three great zones of igneous or volcanic rocks, which are occasionally eruptive, but for the most part interstratified. At the base of the series lies a massive greenstone, which is largely quarried in North Wales for paving setts. This greenstone is a source of perplexity to geologists, since it is often difficult to determine whether it is eruptive, inasmuch as it frequently ignores the laws of stratification, or whether it is stratified, since for the most part it occupies a definite

FIG. 17.

Section of the Llandeilo Strata.

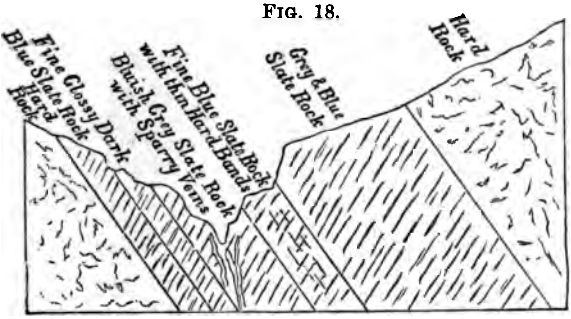


position in relation to the overlying beds. It generally follows the stratification, and seems over considerable areas to form a regular bed. It has long seemed to me that while here and there there may be ridges and irregular masses that mark the openings through which the outflow of molten matter came from the interior of the earth—this matter overflowed the strata below, just as the succeeding porphyries, felspars, and ashes did, and thus we have the double phenomena of dykes and beds—dykes where the original cracks are filled with the consolidated and crystallised molten matter, and beds where this matter had rolled over older beds, to be in its turn overlaid by newer deposits. Above the greenstone comes a thick series of dark slaty beds, 5, often pyritous. These are succeeded by a thick porphyritic rock, 4, which, with the varying felspathic and porphyritic rock, 1, spreads over a large area of North Wales. Between these two lies the great slate deposit, 2, with occasionally, as we shall see, a slate bed interstratified with the lower hard rock, 4.

These slate rocks are pierced by numerous greenstone, felspar, and other hard bands and dykes, 3 3 3, which run at all angles to the plane of the bedding. The beds cover a considerable portion of North Wales, and comprise the slate ranges along lines 3, 3*a*, 3*b*, 3*c*, 3*d*, and 3*e*, of the map and diagram section. Each district has its own special features, and we must notice each separately.

Passing by the patches of Llandeilo beds that lie on the western side of the Cambrian rocks of Carnarvonshire, I will begin with the first outcrop of the beds on the eastern side of that area, represented by line 3 of map. This slate range extends from Criccieth on the south-west to a point between Conway and Penmaen-mawr on the north-east. Fig. 18 is a section of the strata in Cwm Trwscol, and it may be taken as illustrative of the arrangement of the beds

FIG. 18.

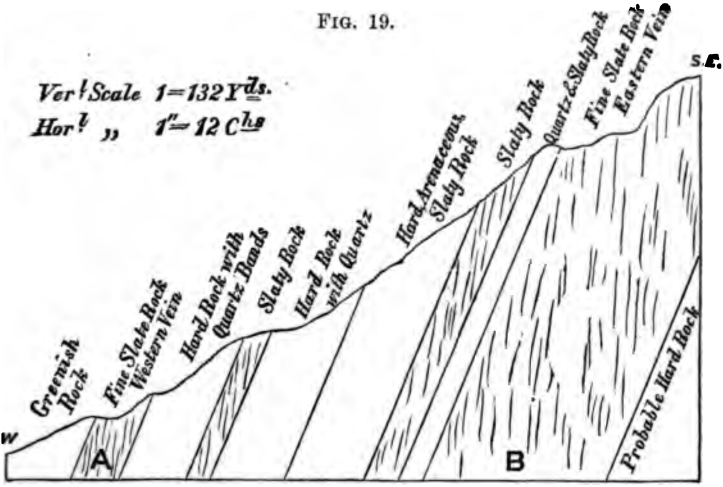

Hard Rock
Fine Glossy Dark Blue Slate Rock
Bluish Grey Slate Rock with Sparry Veins
Fine Blue Slate Rock with thin Hard Bands
Grey & Blue Slate Rock
Hard Rock

Section of Slate Rocks in Cwm Trwscol.
Scale 1″ = 80 *Yds.*

along the range, although there are of course local variations. It will be seen that there are beds of slate of different kinds, and in judging of the character of any quarry along the line, it will be necessary to ascertain in which portion of the strata it has hitherto been worked. At the southern end of the range is Hendre Ddu, or Prince Llewellyn Quarry. In 1873 it employed about twenty men, but at present it probably employs more. Next in a northerly direction is Moelfra Quarry, which is developing. Higher up the Pennant Valley is the Dolgarth or Pennant Vale Quarry. At the present time this quarry is not in work. The slates are strong, but as far as worked to the present time rough. At the head of the valley a small trial has been made in Cwm Dwyfor. The slates there are of a greyish-blue colour, and the cleavage fair. Up another tributary valley, Cwm Trwscol, is the Prince of Wales Quarry. In 1873 this quarry is said to have employed two hundred men, and to have raised yearly 5,000 tons of slate, of the value of 10,000*l.* The slates here are greyish in colour, but, as seen in the section, there are other kinds to be worked. At present, owing chiefly to a great fall of rock, it is lying idle. Crossing the watershed there is the commencement of quarries at Bwlchddeilor and Dinas Lake. The slates here are light blue in colour, having a thin cleavage and smooth surface. There is a great freedom from pyrites all along the range. Beyond Dinas Lake very little has been done by way of trial, indeed the whole district has until very recently been cut off from railway communication. The district is now approached by the North Wales Narrow Gauge Railway, from Carnarvon, and by the Gorsedda Junction Line from Portmadoc, and it will probably receive more attention than it has hitherto received.

From this line the strata dip easterly under the overlying porphyritic rock, and form a trough, in which to the north and south of the line of the diagram section, are piled up the beds that form the mountain masses of Snowdon and Moel Hebog. The strata emerge on the eastern side of this trough, and form a slate range along line 3 A. This range extends from the west of Tremadoc on the south-west to Conway on the north-east. Fig. 19 is a section of the slate beds of this range, with their associated strata. The order of the beds is pretty uniform along the whole line.

FIG. 19.



Section across the outcrop of the Slate Beds at Caergors, near Beddgelert.

The slate bed A, which immediately underlies the upper hard rock, has not been much proved. Some of the old quarries of the Snowdon Slate Co. seem to have been worked in it, but they appear to have been too near a cross line of disturbance to be worked successfully. A quarter of a mile south-west of these old quarries a level, twenty-nine yards long, has been driven into it, and shows some good slate rock. The main slate beds are those marked B. They consist of a series of bluish-grey slate beds, with a fair split, a moderately smooth surface, and, as far as at present worked, quite free from pyrites. The most north-easterly quarry on the range is the South Snowdon, which has now reached a promising stage of development, but it still lacks railway accommodation. Its waggon, with a fine team of horses, traverses the road between the quarry and Portmadoc, a distance of eleven miles daily. Next, to the south-west, is the Snowdon Slate Quarry, on Bwlch Cwmllan. It has a profitable production of about seventy tons of slate a month, but it has machinery and capabilities for a much larger production. Some of the best blue slates in North Wales are made from the present quarries. Following the line south-west there is the Caergors slate property, just leased, and on which there is a small trial quarry. The next property, Gwernlasdeg, is in much the same position. Near the village of Beddgelert there are several slate properties in the very early stages of development. The most south-westerly of these is Cwm Cydd, where there is a good body of accessible slate rock. This brings us to the large quarry of Gorsedda, which has been opened out on a very extensive scale, and possesses a tramway to Portmadoc. This quarry has not been worked for some years, but efforts, which it is hoped will be successful, are now being made to resume operations. Beyond this quarry, to the south-west, there are not any quarries or trials that require notice.

Following the line of the diagram section, fig. 12, eastward, we again see the slate beds dipping under the porphyritic rock, and rising again on the eastern side of the Beddgelert or Gwynant valley. There we reach the slate range along line 3 B. This slate range extends from the banks of the river Conway, near Trefrhiw on the north-east, to near Tremadoc on the south-west. At the northern end are the old quarries of Llanyrwchwyn, with smaller surrounding ones. The strata at this point are much impregnated with pyrites, and for this and possibly other reasons, the quarries are not now worked. Following the line southwards we reach the country between Bettws-y-Coed and Capel Curig, where new quarries are being opened up. There are no trials of any importance between this point and the head of Llyn Dinas above Beddgelert; here at the Castell a trial level has been taken about 240 feet into the slate bed, with good results. The slates are of a dark blue colour, have a fine split, and very free from pyrites. Many slates have also been made from a small open quarry. A quarry of some importance has also been opened on the eastern side of the range at Gerynt. From this point southwards the country is affected by the cross cleavage, to which I have already referred, and by which the slates are broken up lengthwise into ribbons and pencils. Several quarries have had to be abandoned in this district after the promoters had struggled unsuccessfully against the effects of this later and transverse cleavage.

CHAPTER VIII.

SLATE BEDS OF THE LLANDEILO STRATA—continued.

Another curve in the strata brings us to the peaks of the hills Cynicht and Moelwyn, and to the great slate-producing district of Festiniog, on line 3 c.

This slate range contains numerous quarries. It has special features, and altogether it deserves a full and extended notice. The district comprised in this slate range extends from near Bettws-y-Coed on the north-east, to near Llanfrothren on the south-west, a length of about twelve miles. It has an average width of four miles. In the northern part are the quarries of Dolwyddelen and Penmachno—some of them old quarries, but none of them worked extensively, owing to the distance hitherto from railway communication. In the centre are the numerous productive quarries that are ranged about Duffwys. South-west are those of Moelwyn, Croesor, and Cynicht. Further south we again get into the region of cross cleavage, and productive slate quarries cease. Fig. 17 is a general section through the district, which I have adapted from the published section of the Geological Survey. Beginning at the top of the section we have first the porphyritic rock, 1, that overlies the slates; 2 are an easterly continuation of the slaty beds already described in ranges 3 A and 3 B of the general section; 3 3 3 are bands and dykes of massive greenstones and rocks of a similar origin, which here protrude through, and irregularly divide the beds; 4 is the lower porphyritic rock that lies at the base of the great slate zone; 5 is the zone of dark slaty beds, and 6 is syenite, which here takes the place of the greenstone that lies, as I have said, at the base of the whole series. The greater part of the quarries of the range are worked in the portion of the slate beds that immediately overlies the lower porphyries, and they are consequently lower down in the series than those described in the slate ranges of the group already described, and this is a fact which should be well considered in any future quarry operations in those ranges.

The following sections will fully explain the structure of this portion of the slate beds. The distance between Rhiwbach on the north-east, fig. 20, and Rhiwbryfdir on the south-west, fig. 22, is about five miles. Duffwys section, fig. 21, lies between the two. A comparison of the three sections shows a continuation of the same beds, and a similarity of structure over the whole distance.

Fig. 22 shows the strata in greatest detail. Figs. 20 and 21 show the variations in portions of the strata

FIG. 20.

Section of Strata at Rhiwbach.

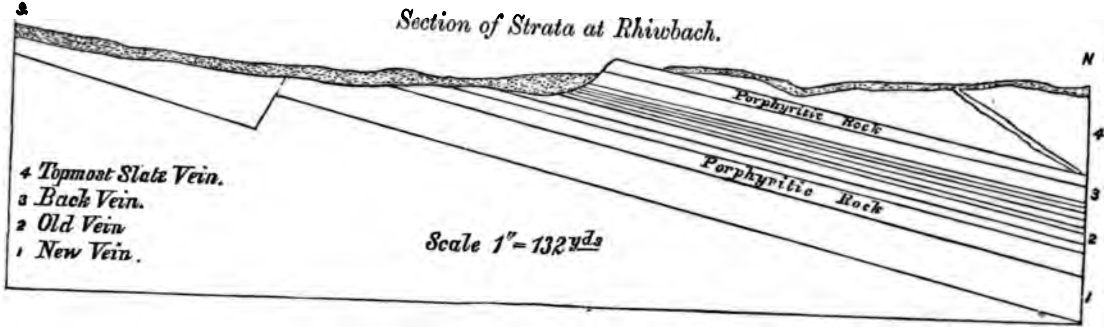


FIG. 21.

Section near Duffwys.

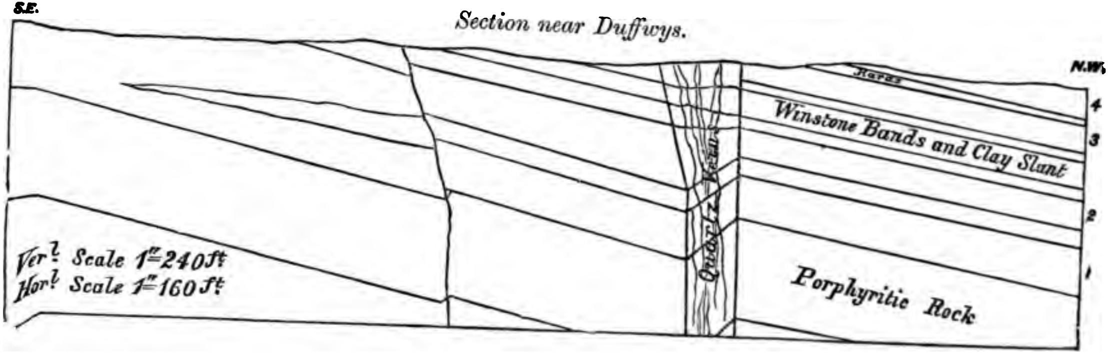
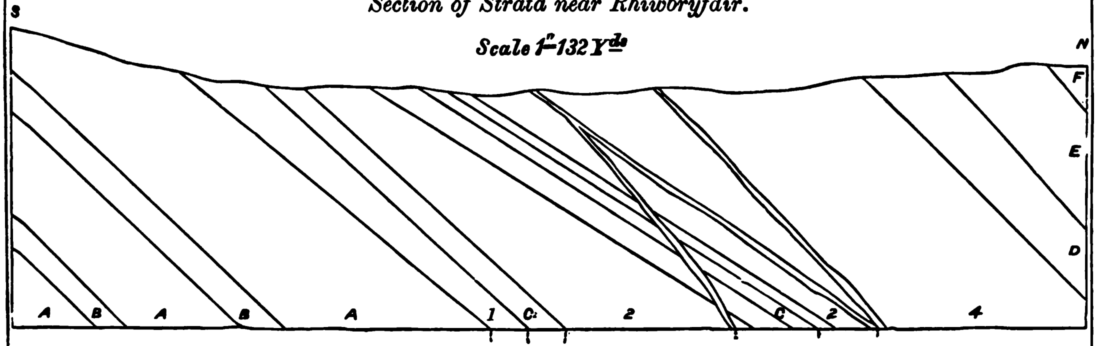


FIG. 22.

Section of Strata near Rhiwbryfdir.

Scale 1" = 132 Yds



A A A. *Lower Porphyritic Rock with*
B B. *enclosed Slate Veins.*
C C. *Groups of Hard Felspathic and Quartz Bands and Veins.*

D. *Hard Slate : upper portion of Top Vein.*
E. *Hard Rock.*
F. *Slate Rock.*

1. *New Vein.*
2. *Old Vein.*
3. *Back Vein.*
4. *Top Vein.*

northwards. At the base of the section, fig. 22, we have the great mass of porphyritic rock which lies at the base of the slate series. This, here, contains two slate beds, B B, which are sometimes merged into one. Overlying this rock is the slate bed 1, which is locally known as the 'New Vein'; it ranges from thirty to forty yards in thickness. About twenty-five yards of thin hard rocks, with interbedded slates, which in fig. 21 are united into one hard bed, separate the 'New Vein' from the 'Old Vein' 2. This is the principal vein of the district. In this section it is at least forty yards thick. Another series of hards and slates, which in fig. 21 are also amalgamated into one bed, but which in fig. 20 again resume their divided character, leads us up to the slate bed 3, locally known as the 'Back Vein.' Another group of felstones, greenstones, and quartz veins follow, and we then reach a slate deposit of great thickness, which we will call the 'Top Vein.' This series probably corresponds with the lower portion of the slate beds worked in the slate ranges to the west, which have already been described.

I will now describe each of the slate beds separately. The lower beds, B B, have not hitherto been much proved in the district. They are said to be worked at the quarries of Glany-pwll, Moelwyn, and Wrysgan, where they resemble the bed to be described next, except that they are of a lighter blue colour.

The New Vein is a bed of good slate, of a dark blue colour, and with a good even split. It is not, however, equal in quality to the Old Vein. It has its 'crychs' and sparry veins and nests of pyrites here and there. In places too it is hardened by contact with the overlying rock, so that its cleavage is destroyed down for a considerable depth. To the north at Rhiwbach it is an excellent bed, 40 yards thick, and its slates will bear comparison with those of the Old Vein, next to be described. Taking the New Vein altogether, it may be said that a large proportion of the slates raised in the district are derived from it.

The Old Vein has been worked for a much longer period, and it is still the favourite vein of the district, the thinnest and most flexible slates of the district being yielded by it. Besides the usual local variations produced by heat, disturbances, and the like causes, its different parts have characteristics of their own, which are well defined and easily recognised by the workmen. The following diagram, fig. 23, with its references, will explain the local names, the relative position and thicknesses of these different portions of the bed.

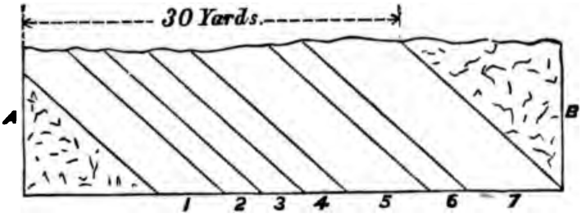
The 'Clay Slant' consists of two thin layers of clay, about half an inch thick, with a bed of slate 9 inches thick, lying between them. It lies immediately under a hard rock, the lower portion of which consists sometimes of indurated slate. The Clay Slant is very constant, and it is to the miners a sure indication of the Old Vein lying below.

The bed varies considerably in thickness. It is about 40 yards thick in some of the quarries about

Rhiwbryfdir, represented by fig. 22. In the quarries near Duffwys, fig. 21, its thickness is reduced to about 25 yards; and further to the NE., as shown in the Rhiwbach section, fig. 20, it has become attenuated to 15 yards, so that it is too thin to work.

FIG. 23.

Section of the Old Slate Vein. Festiniog District.



A B. *Hard Rocks.*

1. *Y Crystin—The Crust.*
2. *Y Wythern Ddu—The Black Vein.*
3. *Y Wythern Fawr—The Great Vein.*
4. *Y Wythern Wen—The White Vein.*
5. *Y Pump Wythern—The Five (Stripes) Vein.*
6. *Y Cryoh Ddu—The Black Curl.*
7. *Under the Clay Slant.*

In Fig. 22 the Old and New Veins are seen to coalesce, the intervening hards having thinned out, and the two beds make a continuous body of slate.

The Back Vein is of the same colour as the two last—dark blue. It is of variable quality, and often contains soft and coarse slates. In some of the quarries, that of the Welsh Slate Company, and Maenoffern, for example, it appears in good condition, and forms a valuable bed of slate. It is sometimes called the

'Barred' vein, because it is crossed by thin bars of hard or sandy matter. The presence of these 'bars' usually necessitate the blocks being split into slates in one given direction.

The 'Top, or Northern, or Flag Vein,' as it is variously described, has been largely worked in the old quarry at Rhiwbach, and it is also worked at several others in that direction, where it has been proved, by boring, to reach a thickness of about 230 yards. The upper part of the bed is generally hardened where it is seen in contact with the overlying hard rock. Hence its split is destroyed, and it is best adapted for the manufacture of slabs. Otherwise the upper portion is usually soft, and where it is worked the slates are derived from its lower beds. It is traversed by diagonal and irregular bands of felspar, quartz, and other hard rocks, one of which is shown in its natural position in fig. 20, as well as by thin sandy beds, usually of a paler colour than the bulk of the slate rock. This bed, as well as that of the Back Vein, deserve increasing attention, especially in their continuation under cover to the N. and NE. For assuming, as we safely may, that the Old and New Veins are not continuous deposits, or at least are so only over a limited area, bearing as they do evidence of having been deposited in hollows of the harder rocks, it is plain that *their* exhaustion is only a question of time, and that not remote. It is therefore to the better portions of these upper beds, which are of great thickness, and are conıuous over a larger area, that we are to look for the ture supply of slates from this district.

Hitherto it has been, as I have already indicated, this Top slate rock, and in those which are seen to be ›ove the hard rock with which it is covered, that the ıarries on the lines 3, 3 A, 3 B, seem hitherto to have ›en worked. Where practicable, it would be very ›sirable for those of the proprietors of those quarries ıo are able to do so to prove, by tunnelling and herwise, the beds that underlie those they work. By reference to the Cwm Trwscol section, fig. 18, it ll be seen that a bed of finer slate lies, as has been cently proved, at some distance below the beds ready worked.

In the heart of the Festiniog district the beds dip, r the most part, due north. This departure from the ual strike or course, NE., at this point is due partly a succession of faults, and partly to the fact that ›re the eastern portion of the strata are bending around d over the northern end of the Merionethshire antinal, to meet the strata of the slate range next to be ›cribed.

The following is a list of the quarries, as they were rked in 1873, with the total amount of produce, and er particulars which may be of interest:—

List of the Slate Quarries in the Festiniog Slate Range.

(Line 3c).

Name	Situation	Probable date of origin	Method of working
Blaen-y-Cwm . .	Head of Machno Valley	Recent	Open
Bowydd or Percivals . . .	Duffwys . . .	1801 Revived by Mr. Percival in 1846	Underground
Bwlch-Slaters .	Head of Machno Valley	Recent	Open
Croesor . . .	Cwm Croesor .	...	Underground
Cwm Orthin . .	Llyn Cwm Orthin	1845 Present Company 1861	Do.
Cwt-y-Bugail .	Head of Machno Valley	Recent	Open and underground
Cynicht . . .	Cynicht Mountain	1876	
Diphwys Casson	Duffwys . . .	1765; Casson 1800; present Company 1862	Do.
Drum	Llyn-y-Drum .	1864	Open
Foel Gron . .	Festiniog, N. .	1850	Do.
Gethin	Above Dolwyddelen	1870	Underground
Glan-y-pwll . .			
Graig Ddu . .	Festiniog, N. .	1840	Do.
Hollands . . .	Rhiwbryfdir .	1835	Open and underground
Llechwedd or Greaves	Do.	1846	Underground
Maenofferen . .	Duffwys . . .	1855	Do.
Moelwyn . . .	Moelwyn Mountain	1865	
Park	Cwm Croesor .	1872	Open
Penllyn . . .	Dolwyddelen, E.	Recent	Do.
Pompren . . .	Do. S.	Do.	Do.
Prince Llewellyn	Do. W.	Do.	
Rhiwbach . . .	Head of Machno Valley	1812	Open and underground
Rhiwbryfdir or Matthews	Rhiwbryfdir .	1840	Underground
Rhiwfachno . .	Penmachno . .	1838	Open
Rhosydd . . .	Moelwyn Mountain	1850	Underground
Rhysgan . . .	Festiniog, NW.		
Welsh Slate Co.	Rhiwbryfdir .	1816	

The production of the whole district for the year ending December 31, 1876, is as follows:—

	Tons.
Shipped from Portmadoc	113,946
Do. sent by rail	26,475
	140,421
To which may be added about 6,000 tons sent from the Penmachno and Dolwyddelen quarries by way of Bettws-y-Coed. . .	6,000
Making a total production for the year 1876 of .	146,421
The total produce for the whole district for the year 1872 was	129,000
Showing an increase in four years of . . .	17,421

CHAPTER IX.

SLATE BEDS OF THE LLANDEILO STRATA—continued.

FOLLOWING the line of the diagram section eastward, we cross the Merionethshire anticlinal, and meet the base of the Llandeilo strata, in the mountain of Arenig Fawr, near the northern termination of the slate range along line 3 D. Standing on Arenig Fawr, we have under our feet the porphyritic rock that underlies the slate beds; and in it and in its southern continuation, on the summits of Aran Benllyn and Mawddy, we find interstratified slate beds, which are the equivalents of the beds, B B, of the Rhiwbryfdir section. When, however, further to the east, we look for the overlying porphyry, we cannot find it: both it and most of the slate beds seem to be absent. It has been supposed that there has been a thinning out of these beds in their progress eastward from the Festiniog district to this point. But as further east still, over the eastern side of the Berwyn Mountains (see diagram section), we shall again meet with the whole series, and as further south—as I shall point out—there appears to be an

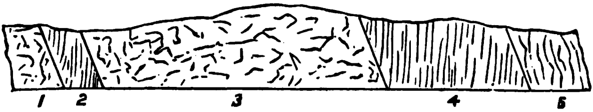
conformity between the same strata and the over-
ng Bala beds, I am led to conclude that at this
int there is an overlapping of the Bala beds upon
ose of the Llandeilo group; that the upper porphyry
d a good portion of the slate beds are thus hidden in
e country between the Arenigs and the north of the
wn of Bala, and that, as there is a great similarity
tween the lower schisty and slaty beds of the Bala
oup and the upper ones of the Llandeilo, this overlap
not discernible on the spot—the porphyritic rock,
ich is a marked boundary between the two, being
iden. In the slaty beds lying above the lower por-
yry, attempts at slate quarrying have been made
the country lying between the Arenigs and the
ns. An abandoned quarry may be seen near the
d of Bala Lake. The strata of this district are a
d deal impregnated with iron pyrites. When, how-
r, we pass down the range to Dinas Mawddy, we
ch the northern end of a very important slate dis-
t that extends from this point until the strata are
t under the marshes by the sea at Towyn. This
tion of the slate range may be described as the
ys, or, as it is usually called, Corris Slate District. I
y here mention that near Dinas Mawddy an im-
tant change takes place in the character of the beds
t usually overlie the slate zone we are considering.
e porphyritic rock loses its massive character and
ses into gritstones. So also does the Ash bed, that
ally underlies the Bala Limestone. The latter, too,

loses its calcareous nature, and is split up into a series of compact sandstone bands. The loss of these distinguishing marks probably led to the error, as it appears to me, when the district was geologically surveyed about thirty years ago, of classing the slate beds of the Corris district with the Bala group. That they are the equivalents of the slate beds of the last three ranges is, I think, sufficiently proved by the fact that at the Minllyn Quarry, near Dinas Mawddy, the uppermost slate bed is quite 2,000 feet below the Bala Limestone, which at that point has not lost its distinctive character. By measuring this thickness of strata on the section of the Bala beds, fig. 26, it will be seen that it brings us down into the heart of the slate zone we have been considering. Besides this, there is an apparent unconformity at this point between the dip of these slate beds and that of the limestone and its associated beds.

FIG. 24.

Section of Strata in the Corris District.

Scale 1 ′= 150 *Yds.*



1. *Hard Rock.*
2. *Narrow Slate Bed.*
3. *Hard Rock.*
4. *Broad Slate Bed.*
5. *Black Rock.*

Fig. 24 illustrates the order of the slate beds hitherto worked in the district. There are traces of beds below the hard rock at the base of the on, but little is as yet known concerning them. hard rock 1 is a spotted gritty rock. 2 is the bed known as the Narrow Vein. It is but a thin ranging only from 15 to 30 yards in thickness. It owever, composed of very pure slate rock; and as -making is largely carried on in the district, the ry operations in it are usually successful. It is ded into two nearly equal parts by a thin line of ling. The best slate rock is found in the lower and the lower portion of the upper half. The ermost portion is often inseparable from the overg hard rock. In the northern part of the district e is a marked absence of joints in the bed, and the seems to harden also in that direction; so that it etter fitted for the manufacture of slabs, which is e carried on extensively. The slates of this and one to be described are of a bluish-grey colour, and free from perishable matter. The lower part of 3 sists of thin bands of hard rock, the remainder of erfectly-formed rough slate, with which are intertified thin slate beds—too thin for profitable work- The Broad Vein, 4, has not as yet been much ked. It is worked at Abercwmeiddau and Minllyn. he former quarry it yields good slates, and by some rrymen it is considered the best bed of the two. At llyn, near Dinas Mawddy, like the narrow bed in same portion of the district, it has few joints, and rather too hard for the manufacture of slates. It yields slabs of excellent quality and of very large size. The production of slates and slabs throughout the entire district, last year (1876), sent off by railway was 26,316 tons, to which must be added a little for local consumption.

List of Quarries in the Corris District.

Name	Situation	Date of origin and slate bed worked	Nature of quarry
ABERCWMEIDDAU	Corris . . .	Broad Vein . .	Open
ABERGANOLWYN[1]	Bryneglwys .	1830 Narrow Vein	Underground
ABERLLEFENI . .	Corris . . .	1500; revived 1810; Narrow Vein	Do.
ALLTCOED . . .	Corris, NE. .	Narrow Vein .	Do.
BRAICH GOCH . .	Do.	1835 Narrow Vein	Do.
CAMBRIA WYNNE	Corris, S. . .	Recent ; Broad Vein (?)	Do.
CWM ERA . . .	Corris, NE. .	Do.	Do.
CWM ODIN . . .	Do.	Do.	Do.
GARWEN . . .	Do.	1820 Present Company 1858; Broad Vein	Do.
HENDRE DDU . .	Hendre Ddu .	Narrow Vein .	Open
MINLLYN . . .	Dinas Mawddy	Broad Vein .	Open

---

[1] A writing-slate manufactory is attached to this quarry. The material used is chiefly the portions of the 'slab rock' which are too small for slabs. These are split into plates, ground with sand and water, and smoothed for use by fine small planing machines. The frames are made by machinery.

CHAPTER X.

SLATES OF THE LLANDEILO STRATA—concluded.
SLATES OF THE WENLOCK GROUP.

I NOW proceed to notice the most easterly development of the Llandeilo strata, near Llangynog, Montgomeryshire, on line 3 E.

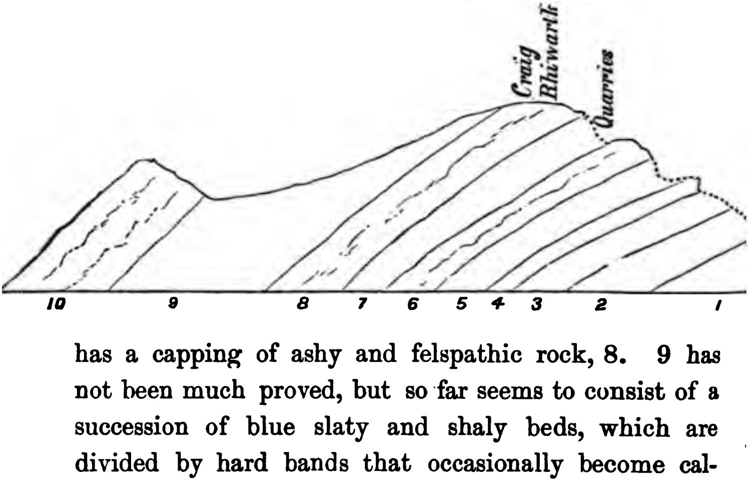
This is an old slate-producing district, the principal quarry, the Rhiwarth, having been worked for about a hundred and fifty years. The district has, however, hitherto been shut off from railway communication, and the heavy cost of carriage along hilly roads has confined quarry operations within narrow limits.

Fig. 25 is a section of the beds at present worked.

At the base of the section we have a zone of dark earthy slates, 1, with interbedded gritstones. 2 is a hard rock, which, as usual with such rocks, varies greatly in composition, but which is at times highly porphyritic. We have little difficulty, I think, in recognising this rock, from its position and character, as the equivalent and eastern continuation of the similar rock underlying the slates at Festiniog. Above this there is a slate bed, 3, twenty-five yards thick. Twelve yards of hard rock, 4, succeeds, followed by another slate bed, 5, twenty yards thick. Another hard rock, 6, leads us to the uppermost bed of slate rock, 7. This has a capping of ashy and felspathic rock, 8. 9 has not been much proved, but so far seems to consist of a succession of blue slaty and shaly beds, which are divided by hard bands that occasionally become calcareous. This series dips under a greenish rock, 10. It is easy to see a general resemblance between the whole series and the succession of strata near Festiniog, and this resemblance will, I think, become more complete as the upper beds, 8 and 9, become more fully known. Of the slate beds the lowest, 3, has not been much worked so far, but it is said to contain some good slates. It is from beds 5 and 7 that the slates are now made. The upper parts of these beds, as is usual, often become hard and difficult to split as they approach the

FIG. 25.

Section of Strata at Llangynog, Montgomeryshire.



overlying hard rock. The slates are of a dark blue colour. They are tough and hard and exceedingly durable. They are quite free from iron pyrites. A little roughness is imparted to the surface by coarser lines of bedding by which they are crossed, and the slates are somewhat heavy. There are local variations, and some portions of the beds are less affected than others. At the most these circumstances do not hinder the sale of the slates, which are much prized for their other good qualities.

Trials have been made in the group of beds 9, which show slates of a similar character to the Rhiwarth slates, but of a smoother surface.

Besides the Rhiwarth Quarry there are no others at present producing slates, but there are several in the very early stages of development, and the introduction of a railway or tramway would largely stimulate enterprise in the district.

The produce of the quarries at Llangynog and Maengwynedd last year was as nearly as possible 2,300 tons.

SLATES OF THE WENLOCK STRATA.

Lines 4.

We have now to consider the uppermost group of strata from which the slates of North Wales are derived. The group takes its name from the little town of Wenlock, in Shropshire, around which, in shale and

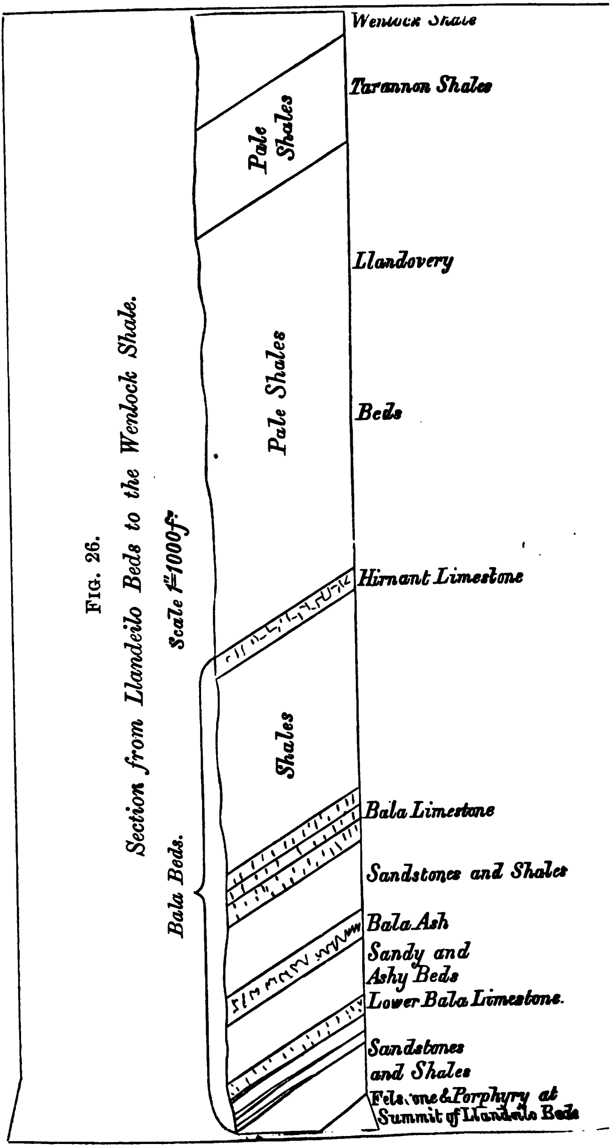


FIG. 26.

Section from Llandeilo Beds to the Wenlock Shale.

Scale 1" = 1000f.

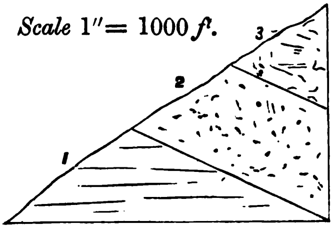
stone, the group is well represented. The strata North Wales are known to be the same by the ntity of fossils, as well as by their stratigraphical tion, but the beds of the Principality have a vastly r look than their equivalents in Shropshire. Fig. will help the reader to understand the relative posi- of the Wenlock beds, to those of the Llandeilo es last described.

In this section, at the base of the Wenlock shale, be seen a band of pale slates, which is known geo- cally as the 'Tarannon shale.' Openings for slates e been made in these beds at many places along r course. The only approach to a quarry in them t Clegir, Bettws Gwerfylgoch. A good number of nd and third class slates were made at this quarry. y were of a cream colour tinged with green. The ur was exceptional, it was not objected Owing to its situa- n and other causes the rry is not now worked.

FIG. 27.

Detail Section of Wenlock Beds.

Scale 1″= 1000 *ft*.



1. *Slates and Flagstones.*
2. *Gritty Beds.*
3. *Blue Rubbly Beds, sometimes Slaty.*

Fig. 27 shows the eral order of the nlock strata in North les. It is in the lower ls, 1, that the slate rries are worked, al- ugh occasionally the er beds become slaty. The cleavage is usually nearly horizontal in these beds, while it is generally vertical in the beds already described. Bands of hard rock are interstratified with the slate beds, and at Penarth Quarry, near Corwen, the slates are capped by a compact gritstone, which is thought to be hard enough for the manufacture of paving setts. Between these hard beds the split is usually very good, the slates splitting thin and straight. The material is tolerably free from pyrites. The slates are softer than those from the Llandeilo and Cambrian beds, but they are very marketable, and make a good roof. The house in which I write bears the date 1758, and, as far as I know, the roof, which is covered with these slates, has never been disturbed. They have, however, a very ancient look.

The quarries follow the lines of the outcrop of the strata, as shown on the map.

The following are the quarries now in work: Clettwr near Llanderfel, Penarth near Corwen, Oernant and Cloggau near Llangollen, Llangollen Slate and Slab Company, Glyndyfrdwy, between Llangollen and Corwen, and Moel Ferna near the last; the Cambrian in Glyn Ceiriog, and the Wynne, one of the oldest quarries of the range in the same valley.

There is also a quarry devoted chiefly to the manufacture of slabs in the hills flanking the Vale of Clwyd. There are several new undertakings, among which I may mention Nantyr and Nantgwryd in Glyn Ceiriog, two or three near Corwen, the same number near Bettws Gwerfylgoch, and I doubt not that in time the almost unknown and inaccessible region lying between Bettws-y-Coed and Llanrwst, and the Vale of Clwyd, will have its slate and slab quarries. The production from the whole formation in North Wales last year may be taken at 20,000 tons.

CHAPTER XI.

SLATES OBTAINED FROM OTHER DISTRICTS IN GREAT BRITAIN AND IRELAND, AND IN FOREIGN COUNTRIES.

It will now be necessary to notice other districts and countries where slates are obtained from the various groups of strata we have already considered. The description will necessarily be brief, owing, first to the paucity of information that exists concerning slate operations in those places, and secondly the, at present, very limited total production as compared with the slate production of North Wales.

In the centre of England there is a patch of the older Cambrian rocks thrown up at Charnwood Forest. Here slates somewhat rough and heavy, as far as my recollection serves, are made on a limited scale. The quarries have, however, been worked for many years. In Wicklow, Ireland, slates are obtained from corresponding strata. The Arenig beds are represented by the Skiddaw slates of the north of England, and near Maryport slates of a greenish tinge are largely obtained from this formation. Slates are also obtained from the same strata at Soulby near Ramsay, in the Isle of Man. At Angers, which is one of the oldest slate-producing districts in France, slates of a dark blue colour, like those obtained from similar rocks in North Wales, are derived in underground quarries. One of the most important slate quarries of Canada is the Walton Quarry, in the sixth range of Melbourne, it is worked in the Quebec group of strata, which is the equivalent of the Arenig beds. The slate bed at this quarry is described as being the third of a mile in breadth. The slates split thin, and have a smooth surface. They are fine-grained and purple and blue in colour.[1]

In assigning the geological position of slates in other countries we labour under the disadvantage that arises from the fact that the exact succession of the older strata is not always as well-defined and decided as it is in North Wales, so that in enumerating the localities where slates are obtained from beds of Llandeilo age I may possibly include some which more properly belong to groups above and below. In Pembrokeshire quarries have been opened in the Llandeilo beds, but hitherto slate quarrying has not been very successful in the southern counties of Wales. Among the quarries of Pembrokeshire may be mentioned those of Gilfach, Rosebush, and Cleddau Valley, from which slates of a light blue and of a greenish-grey colour are made. In Scotland quarries are worked in beds of this age, but for the most part the cleavage is imperfect, the beds being sandy and existing in a hardened and altered condition. In the north of England, and in the Isle of Man, there are quarries labouring under similar disadvantages. Slate quarries are also worked to some extent in the same beds in Ireland. The quarries of Killaloe in Tipperary are of considerable importance. These quarries are described by Mr. Hull [1] as laying open a section of over 350 feet, and produce slates of a dull bluish-grey colour, and of good quality, though somewhat rough. Mr. Hull adds: 'It is not improbable that the west and south of Ireland may be found capable of yielding far larger quantities of this valuable commodity than hitherto, but which for want of capital and perseverance have not been rendered available. Amongst the Lower Silurian rocks north of Hillary Harbour, and along the valleys of the Erriff and Doo Lough in Co. Mayo, are certain beds, which, if opened up at sufficient depth, might be found to produce excellent pale grey or bluish roofing slate; and to this district I venture to direct the attention of capitalists.' [2]

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[1] Logan, *Geology of Canada*, p. 830.

Four quarries are mentioned as being worked in Sweden, which may be in these beds. Of these the slates from three are thick, but those from the quarry at Kjellsvik, near Lake Wena, are fine-grained, of good quality, and comparable to those of North Wales.

It is probable that of the same age are the slates of oravia and Silesia. 'They extend throughout an tensive tract of country, the chief seat of the industry ing Waltersdorf near Olmütz. The slates vary from ey to blue and black, and are receptive of a good lish, on which account they are not only employed flagging and roofing purposes, but also for tables, ces, and cisterns.'[1]

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[1] *Building-stones of Great Britain*, p. 297.

[2] *Ibid.*, p. 298.

Roofing slates are obtained from the same beds in United States, at Barnard, Bingham, Kennebec, d Pascataquies, in the State of Maine; at Boylston, rvard, Lancaster, Pepperell, and Shirley, in Massausetts; at Brattleborough, Dummerston, Tourhaven, d Guildford, in Vermont; at Hoosic, New York; Bush Creek, and near Unionville, in Maryland; and the Cove of Wichalla, in Arkansas.[2]

From the equivalent of the Wenlock beds the pale ue and green slates of Kendal and Ulverstone, which very marketable slates, though somewhat heavy, are rived. These slates are very similar to those of egir, near Corwen, from the Tarannon shale, at the e of the Wenlock beds. And from beds of the me age in Canada the dark blue slates of Orford are rked. Similar slates are also obtained at Brompton d Westbury, on the lower St. Francis. The whole of ese Canadian slates are described as not being so ooth in their cleavage as those worked in the Arenig Quebec rocks of Melbourne.

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[1] *Building-stones of Great Britain*, p. 300.

[2] Dana, *Manual of Mineralogy*, p. 358.

Slates from Devonian Strata.—Passing now to strata higher in the series than those we have hitherto considered, we find that the Delabole Quarries of Cornwall have been for a long period worked in the Devonian strata of that county. In the year 1839, the late Sir H. De la Beche wrote: 'The Delabole Quarries have long been celebrated for producing a beautiful and durable material, combining considerable lightness with strength.'[1] The beds worked belong to the lower portion of the upper division of the strata. Other quarries have been worked in the same beds, but none of them call for special notice.

Slates are worked in the Devonian rocks at Valencia, in Ireland, where they have a greenish tinge, but are rather thick and rough. They make excellent flags, and these were largely exported to England before the flag trade of Wales assumed its present importance.

In France Devonian rocks are largely quarried for slates, in the Ardennes, at Deville, Fumay, and Rimogne. The slates of Luxemburg belong to the same group, and are quarried at Bertrix, Geripont, and Herbeumont. In Nassau, Westphalia, and Rhenish Germany generally, as well as in Wurtemburg, the schists (Schiverstein) that underlie the upper Devonian limestone yield slates. There are quarries near Coblentz, Caub, Giessen, Friedeburg, and Wittgenstein.

Slates of the Carboniferous Strata.—Ascending still higher in the geological scale, we find that the ower portion of the Carboniferous beds, consisting of grits and shales, frequently assumes a slaty character. Numerous quarries have been opened in these beds in Devonshire. The results are, however, frequently disappointing, owing to imperfect cleavage, the irregularity of the materials, and the presence of pyrites. 'A line drawn from St. Genny's, on the coast southward towards Plymouth, curving round the south-western part of Dartmoor, is the strike of the Carboniferous beds. The slate bed is quite at the base, is opened on at various places, but with indifferent success. The cleavage is at a slight angle (from the bedding). There is much dark carbonaceous matter mixed with the slate. The roofing is heavy, and apt to split on exposure. The flooring is good, especially for indoor work.'[1]

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[1] *Report on the Geology of Cornwall and Devon*, p. 503.

We have now reached the uppermost limits of slate proper. Thin flagstones are found associated with the Millstone Grit and Coal-measures, and are sometimes used for roofing purposes. The thin calcareous flags that lie between the Bunter and Keuper sandstones in Shropshire, at Grinshill, were formerly used for the same purpose. In Italy roofing slates are largely quarried from altered beds of Liassic age, the best slates being produced in quarries near Genoa. Around Oxford the buildings are covered with similar thin flags from the 'Stonesfield slate' of the Oolitic series. The stone is *mined* underground, and brought up by shafts to the surface. The blocks are left exposed to the action of the weather during a winter, when they are readily split up into thin layers, which are then dressed for use.

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[1] S. R. Pattison, *Letters to the 'Mining Journal' on Slate and Slate Quarries*, 1866, p. 13.

CHAPTER XII.

THE EARLY HISTORY OF A SLATE QUARRY.

E site for a slate quarry is generally discovered by
e or more workmen who are already employed in an
isting quarry. In all quarries there are men pos-
sed of more than usual intelligence, who like explora-
n and discovery for its own sake, and who are also
sirous of bettering their position by either investing
eir savings in the working of a quarry on a small
le, or in developing it to such an extent that it may
come a marketable property, which by its sale shall
ing to them a considerable sum of money, over and
ove its actual cost to them, as a reward for their
terprise, knowledge of the country, and the risk of
ss they have incurred. Many mistakes have been
ade by such men in time past, through their want of
e simplest scientific knowledge; but it is to them
d to men of like tastes, of an exploring turn, though
connected with quarries, that the largest and most
ccessful of slate quarries owe their origin. In tracing
e early history of a quarry we will suppose that our
venturer is a judicious man, and that his discovery is

intrinsically good. His discovery is made by inference and search combined. By inference frequently in the first place. He knows the direction taken by the slate bed he works, and he infers that its continuation is probable in that direction, and that if he searches for it, even at some distance from his present quarry, he will find it. In this expectation he is often rewarded by seeing the outcrop of the slate bed on the hill-side. If, however, the rock is covered with peat and soil, he betakes himself to a ravine in which a stream has worn its way down to the rock. Sometimes, by dint of patient exploration alone, in an unfrequented locality, and not guided by any scientific knowledge, his discovery is made. Having satisfied himself of the colour, quality, and cleavage of the rock by a few small trial holes made by pick and crowbar, and with the utmost secrecy, his next point is to obtain from the owner of the mineral rights of the property a take-note or agreement for a lease. This instrument conveys to him the power to search for slates, and it may be other minerals. It defines the sum to be paid by way of dead rent, the duration of the lease, the amount of royalty to be paid to the lessor for slates raised during the period of the lease, and sets forth rights of way, water, and other matters affecting the working of the property. It will be seen at once that this is a critical juncture in the history of the infant undertaking, and that whether the adventurer will continue to work it himself, or having proved the property sell it to others, very much of the ccess or otherwise will depend upon the terms of the ase. It will be well, therefore, at this point to conder the basis on which a lease should be granted and cepted.

Time.—Leases are sometimes granted for twenty-ne years only. This is the customary period for eases granted by the Crown. This time is too short, nd should never be accepted unless with an underaking on the part of the lessor to renew at the expiraion of it for a similar term. Considering the outlay required on a slate property to bring it into successful work, the lease should on no account be for a less time than thirty years. If a considerable outlay on the construction of tramways and other outside works is required, the lease should be for a term of fifty years. Numerous leases have been granted for this period in North Wales. Forty years is an ordinary term. The term should, in any case, commence from the date of the expiration of the take-note. It should also contain a proviso enabling the lessee to surrender it, in case of unprofitable working, at any time, on his giving due notice to the lessor to that effect.

Royalty.—The royalties now paid by lessees of slate quarries are various. They are usually a proportionate part of the selling price of the slates at the quarry. I have an instance before me where the royalty payable s one-eighth. This is far too high. In the Festiniog district the average royalty is one-twelfth. In Carnaronshire we have examples of its being one-fourteenth, one-fifteenth, one-sixteenth, and one-twentieth. One-fifteenth may be considered a fair royalty, slightly in favour of the lessee. Sometimes the amount is regulated by a sliding scale, the royalty increasing every five years from a starting point of one-twentieth, and rising up to one-twelfth, with the promise of an ultimate renewal of the lease at that amount. This seems an equitable arrangement, for the cost of production of slates is to the lessee higher during the first years of his enterprise than it should be afterwards. Occasionally there is a fixed charge per ton. I have an instance where this, in a quarry situated a good way from railway communication, is 1*s.* 6*d.* per ton on slates, and 9*d.* per ton on slabs. Taking the present average price per ton at 60*s.*, this would be only equivalent to one-fortieth—an exceptionally low royalty. Care should always be taken that the royalty is payable only on slates actually sold during the year.

Dead Rent.—By way of acknowledgment on the part of the lessee, and as a guarantee to the lessor that his property shall be worked, it is usual to fix a certain sum which, whether slates are produced or not, shall be payable to the lessor. This is the dead rent, and it is always provided that it is mergeable into the royalty, and not to be paid in addition to it. Considering that it is the expenditure of the lessee's money that is to develop an income for the lessor, and that the former takes all the risks, this rent should be as low as possible. In slate quarries during the term of the take-note

erally fixed at five pounds a year. The lease
vides for twenty pounds a year. It ought not
l this latter sum. Sometimes a fixed rent is
instead of royalty. I quote an instance in
he agreement for an undeveloped property
over a term of twenty years. The rent is
as follows:—Five pounds a year for the first
s, ten pounds a year for the second five years,
ounds a year for the third five years, and twenty
year for the fourth five years, with power to
e to obtain a lease for a second term of twenty
a royalty of one-fifteenth. This, for an unde-
property, is an equitable arrangement.

pensation for land taken.—Besides the dead
royalty, the lease usually provides for compen-
be paid to the owner and the occupier for land re-
r quarry purposes. Where a quarry is situated
closed land, compensation to the tenant only is
, and mountain land is valued for sheep-grazing
3*s.* per acre. Where land is enclosed, and the
ceives a rent for it, he will require to be re-
liberally for the loss of his rent. Usually the
ys rent varying from 1*l.* to 4*l.* per acre a year.
ally the lessor requires a cash payment for
en of rather more than its agricultural value,
y where the land is taken for building pur-

-leaves and Water-rights.—It is important
se should be well secured. If the quarry

property does not abut on a railway or road, powe should always be taken to cross the lessor's land withou way-leaves as far as it extends. The lease generall winds up with the usual arbitration clause. In applying for a lease the discoverer often associates wit himself one or more partners, to share the cost, responsibility, and profits, and the lease being obtaine to their satisfaction, they are ready to commenc proving the ground.

CHAPTER XIII.

THE EARLY HISTORY OF A SLATE QUARRY—continued.

If the quarry is to be an underground one, worked from the face of a hill, it will be best proved by driving a tunnel into it at a point where it will be convenient subsequently to form a floor. In which of the positions shown in fig. 29, will depend upon the means at command. For the simple purpose of proving, the upper and shorter tunnel will be sufficient. This should be taken right across the bed, and if possible a short cross-cut or tunnel driven right and left of the end of it. This will prove the character of the slate rock, and make the commencement of a couple of chambers easy.

If the quarry is to be an open one, worked in galleries on the side of a hill, it will be a matter for consideration whether it will be most advisable to drive a tunnel or to make an open cutting into the rock. If the ground is covered with drift, or if hard rock lies on the face of the bed, as in the left-hand base of fig. 19, or if the hard rock rises up to the surface to almost a level with the topmost outcrop of the sla bed, it will be better to drive a tunnel; but if the sla rock comes up to the surface, as in the upper porti of fig. 19, if the ground rises sharply, and the outcr of the rock is pretty solid, it will be better to make open cutting wide enough—say 10 to 20 yards—to fo the commencement of a gallery. The cutting tunnel should be arranged so as to form a galle which shall be convenient to other galleries that m be subsequently formed above and below. If the qua is to be an open one, worked below the level of ground, a shaft should be sunk on the side on which incline rests in fig. 32, from the bottom of which tunnel may be taken parallel with that side of the quar If the quarry is to be an underground quarry, work by means of a shaft, a shaft, in the position of winding shaft in fig. 31, should be sunk, and a tun driven either *along* the bed, which shall communic with chambers to be formed, or one driven across bed, to prove it in the direction of its outcrop. Wh there are quarries worked in the immediate neighbo hood, and the quality of the bed known in them, sim boring in the case of the two last quarries may sufficient.

Supposing the result of the above operations to satisfactory, the adventurers may consider the prope proved, and it may fairly be considered to have b brought into a marketable condition. They m now have the command of sufficient money to compl the works and make the necessary communications with a railway or port, but usually, as may be supposed, this is not the case, and at this point they desire to sell the property they have thus proved to others who have means for its further development. In endeavouring to do this the first steps taken by them is to obtain 'reports' on the property from neighbouring quarry managers of repute, and especially from those who have been successful in their own quarries. In addition to these reports it is also advisable for them to call in a recognised authority on such matters from a distance, who shall go over the ground with the local reports in his hand. The reports being satisfactory the next step is to introduce the quarry to capitalists who may be disposed to enter into such undertakings. This may be done directly by one or other of the adventurers, or through an agent who is supposed to have an acquaintance with such persons. One or more gentlemen having been found who are disposed to consider the matter with a view to purchase, they on their part send their own mineral surveyor, mining engineer, or other confidential adviser on such matters, to inspect the property. As the welfare of his clients and the future of the undertaking depend upon the result of his examination, it is essential that he should take the greatest possible care in his examination of the property.

The chief points to which he will direct his attention are the following:

1. The examination of the take-note or lease.

2. To see that the ground is not broken up by faults, and that it is not contiguous to any considerable disturbance of the strata.

3. That there is plenty of room for the working of the quarry, and for the disposal of the waste off the slate rock.

4. The amount of water-power.

5. Whether the débris and slates that may have been made show signs of rust or decay.

6. He will minutely examine the character of the rock along the course of the tunnel or in the open cutting or shaft; noting: *a*, if the natural joints are too numerous to admit of slates of a good size being made; or, *b*, if the joints are so far apart as that the rock will require a large amount of cross-cutting or sawing; *c*, he will observe the frequency or otherwise of the occurrence of posts or bands of hard rock, and how these will affect the working of the quarry. He will readily distinguish these, either by their smoothness and compactness, or by their gritty and ashy character, both of which will contrast with the general appearance of the slate rock, whose broken edges will show the peculiar wrinkled appearance known among Welsh quarrymen as 'pleri' or 'pillari.'

7. He will direct, and this is a point on which usually he will have to insist, that blocks of slate rock be blown out of such parts of the level or opening as he may choose, and these he will have split and dressed

n his presence. He should arrange on the first day of is visit, or immediately upon his arrival, that this hould be done, in order that the operation should ot be hurriedly performed, otherwise the rock may be hattered and the result be unfairly unsatisfactory to he quarry.

8. In observing the split he will notice if the block plits kindly all the way down from the top, or whether t has to be much humoured by side operations, whether the split is thick or thin, whether the surface of the slate is smooth or rough. He will see if crychs, bends, and cramps cross the blocks so often as to prevent large size slates being made from them without isfigurement. He will notice the colour of the slate—lue of various shades being the standing colour—the edom of the slates from parti-coloured bands or bons, its freedom from pyrites, and from carboneous and other objectionable matter.

9. Railway and shipping communication will also uire his attention, and here he will consider the ility with which a tramway may be constructed, ether it may be connected with a railway or other blic outlet on the property of the owner of the quarry, by the payment of way-leaves to other proprietors; e necessity for inclines, the length of these, with obable cost, together with the nature of the ground ver which the tramway will have to be made, will demand his attention. It would, indeed, be the perfection of a quarry where everything would be perfectly

satisfactory, and the combination of all desirable advantages is not to be expected, and the business of the inspector will be to balance the various drawbacks and advantages, and so arrive at his decision.

Supposing his report be a satisfactory one, the question that next arises is, the amount of the price to be paid to the original adventurers for the acquirement of their interest in the property: for it will be readily conceded that they are entitled to a consideration for their enterprise, intelligence, and the risks they have incurred.

The price paid for slate properties necessarily varies greatly, and it is affected by many considerations, as whether the spirit of enterprise is jubilant, or, as at the present moment, depressed. In times of speculative mania, almost fabulous sums have been paid for these and similar properties among collieries and mines. The price will also be affected by the law of supply and demand for such properties. The following considerations may be helpful to the purchaser in determining his side of the matter: —

1. What unusual advantages, as to royalty, time, and other matters has the vendor secured in his lease, and what at this juncture is the value of them to the purchaser?

2. What are the natural and commercial advantages of the quarry—the first as they affect cheapness of working, the second as they affect transit to the market?

3. Have the testing operations been judiciously con-

ducted, and have they, by their completeness lessened greatly, or entirely removed, the risk of failure? For it is clear that it is better to pay a good price for a property thus proved, than half the sum where the risk of failure remains.

4. Supposing the future earnings of the quarry will be 20 or 30 per cent. for a period of thirty years, what would be the capitalised value at either of these rates of the interest on sum already expended by the vendor, together with the principal itself?

5. What bonus does the vendor deserve for originating the undertaking?

6. What further amount of money will be required for its development, and what is the property worth as it stands to the purchaser?

Special considerations will arise in each particular case which will have to be determined between buyer and seller. The following examples of recent sales may be of use:

1. Slate bed a mile in length, 250 yards wide. Small cutting made into slates. Slates split fairly well. Royalty one-fifteenth. Lease fifty years. Price 1,200*l.*

2. Slate property with two beds of slate, one 25 yards, and the other 250 yards wide; both nearly a mile long; ground 800 acres. Railway provided to run through property; present distance from terminus two and a half miles. Lease thirty-three years; royalty, one-fifteenth. Tunnel 30 yards in slate rock; small open quarry; slates good. Price 1,500*l.*

3. Freehold slate property, 30 acres, seven cottages close to tramway; small quarry; two bargains in full work; working at a profit. Slate rock equal to 3,000 tons a year for thirty years. Price 7,500*l.*

4. Open quarry; four bargains opened; slates blue, thin, smooth, and good; one and a half miles from tramway; water-power. Lease forty years. Royalty one-fifteenth. Price (asked in this case) 7,000*l.* No railway inclines or outside erections.

It is usual, whatever price be fixed upon, for the money to be paid by instalments, payable over a given time. I need hardly say that when several agents stand between the purchaser and vendor, the price is inevitably increased; and that one drawback to the success of public companies is the great cost often incurred in their construction; to which is frequently added large sums for promotion-money; so that the concern is often saddled with a dead weight from its commencement.

CHAPTER XIV.

E MANNER AND COST OF DEVELOPING A SLATE QUARRY UP TO A GIVEN PRODUCTION.

PPOSING the terms of the purchase have been ar- ged, the property has now to be brought into rking order, and it is for us in the next place to uire into the best manner of doing this, together th cost of the work up to a certain point, from ich point the property may be most extensively veloped, either slowly, by laying aside a portion of e profits for the purpose, or quickly, by the employ- nt of fresh capital for the purpose.

If the stage proposed be reached successfully, the penditure of money in the construction of inclines, mways, reservoirs, offices, and houses, may then be ely undertaken, and the amount necessary for these *side* works will form the subject of a separate in- ry.

In all quarry operations it is of the utmost im- tance that there should be as few day-workers as possible. The work should be by contract, and the removal of waste and top rock should invariably be by weight. One of the first things, therefore, in the beginning of a quarry is the purchase of one or more weighing-machines, over which the rubbish-waggons may be taken and weighed. The prices paid for various kinds of work in the following estimates are the average of those paid for similar works at the present time. The estimates will, of course, be affected by local considerations, but they will be sufficiently near for all practical purposes.

1. *Open quarry, to be worked in galleries on a hill-side.*

I propose first to estimate the cost of developing an open quarry upon a hill-side to the extent of eight slate bargains, estimated to produce altogether about 250 tons of slate a month. To provide space for the working of these bargains we should want two galleries of four bargains each. We will assign a space of ten yards in length for a bargain, and on this calculation each gallery should be forty yards in length, rather more than less. The face of a gallery from the floor of one gallery to that of another is fifteen yards—occasionally more. The width of a gallery from its face to the face of the next behind it should not be less than twenty yards; so that for each gallery a space of forty yards by twenty would have to be cleared; and, allowing for the slope of the hill, this clearance would be at least to an average depth of eight yards.

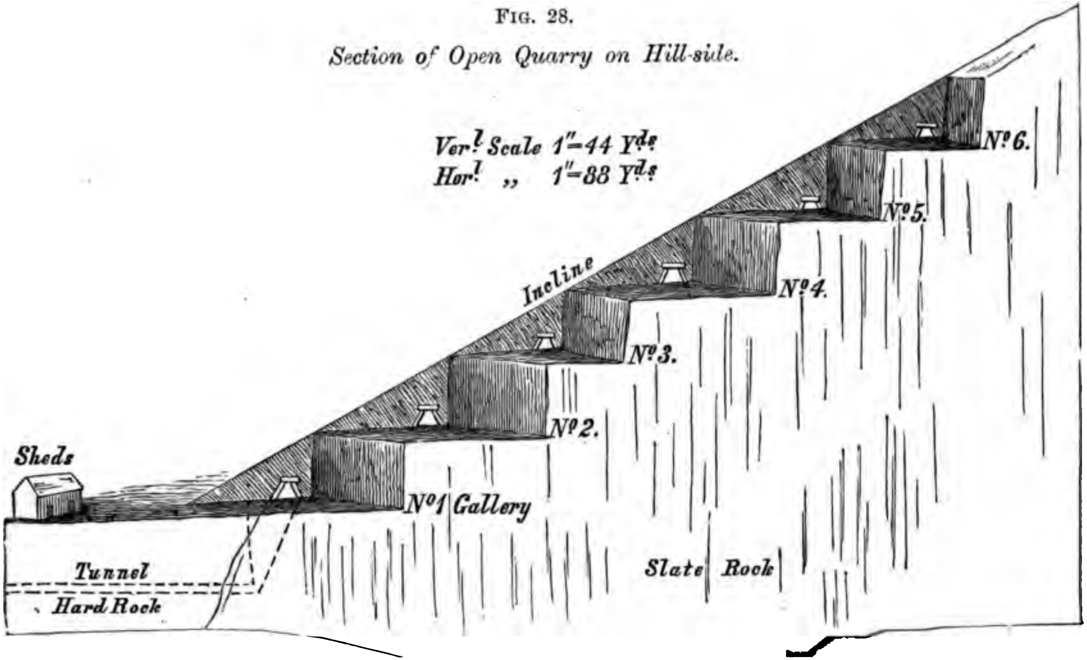
Fig. 28 represents a section of a quarry of this description. The face of the incline shows the actual slope of the hill on which it is proposed to open the quarry. From the steepness of the face and from the fact that the slate rock crops out on the surface, the works will be begun by open cuttings; but if at any time a gallery is opened below No. 1 it will have to be approached by a tunnel through hard rock, from the end of which an opening 1A will be made to the floor of No. 1 gallery. Such communication will be made by sinking down from that floor, and by opening up from the end of the tunnel simultaneously.

Before commencing operations it will be necessary to fix the position of the incline, which will be placed so as not to interfere with any extension of the galleries in that direction, or with the working of them.

It is proposed to start with gallery No. 3, and to take an opening forty yards wide into the hill, until it presents a face of solid slate rock fifteen yards in depth. At this point gallery No. 4 will be commenced, though possibly some clearance as a preparation for it may be begun before. This No. 4 gallery will also be carried the same width into the hill until it also presents a face of solid face rock fifteen yards deep. A third gallery, No. 5, will be begun in like manner, and carried into the hill about half the width of the others, when it will be possible to work Nos. 3 and 4 together, the No. 3

FIG. 28.

Section of Open Quarry on Hill-side.



having previously been brought into operation. The cost of clearing top upwards from the middle of No. 5, will be chargeable to revenue account. The galleries Nos. 1 and 2 may be formed, and the length of the galleries extended, as I have said, out of revenue or capital, as the case may be.

The cost will be as follows:—

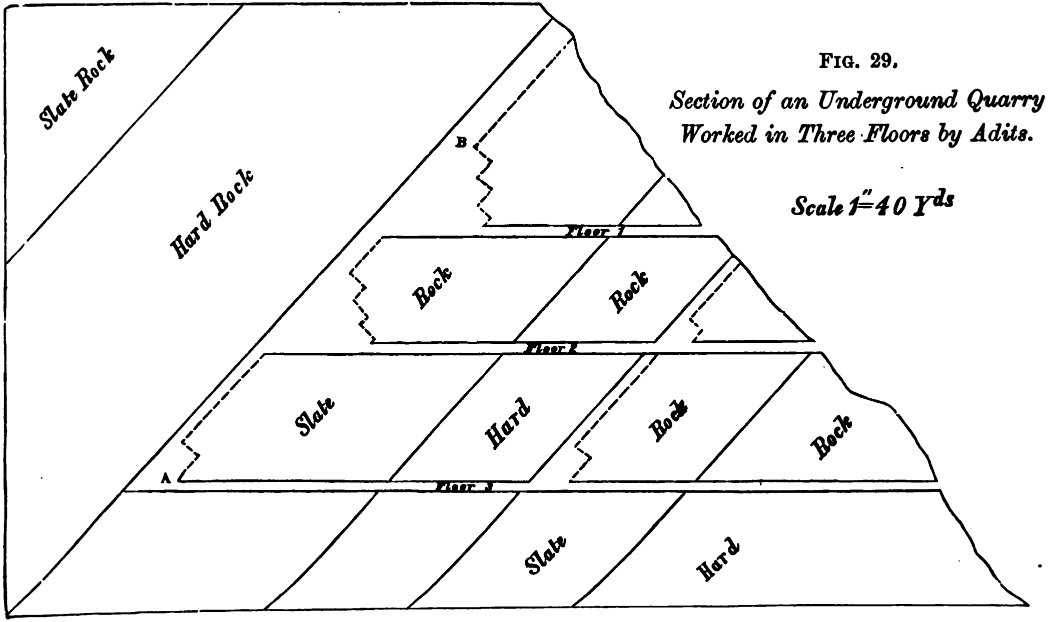
	£	s.	d.
Clearing top rock for gallery No. 3, 40 yds. × 20 × 8 yds. deep; 6,400 cubic yards = 12,800 tons, at 1*s*. per ton	640	0	0
Do. for gallery No. 4	640	0	0
Half do. for gallery No. 5	220	0	0
Taking 30 tons of slates as the monthly production of an ordinary slate bargain, the quarry would be equal to a production of 240 tons per month of four weeks. To work the quarry, the following plant would be required:—			
Twenty slate or tram waggons, at 7*l*. . .	140	0	0
Five tons 16-lb. bridge rails, 6*l*. 10*s*. . .	32	10	0
400 sleepers, 1*s*. 3*d*.	25	0	0
Spikes	3	0	0
Two weigh-machines and sheds, 20*l*. . .	40	0	0
Smith's shop and tools	100	0	0
Small barracks	80	0	0
Sundry tools and appliances	100	0	0
Manager and odd labour, two years . .	300	0	0
Contingencies, 10 per cent.	272	0	0
	£2,592	10	0

f which 1,500*l*. would be spent in the quarry, and he remainder on plant and materials.

FIG. 29.

Section of an Underground Quarry Worked in Three Floors by Adits.

Scale 1″=40 Y^{ds}



Chambered quarry worked underground by means of adits or levels.

In a quarry of this description the floors answer to e galleries in an open quarry, although if the slate ck be twenty yards or more in thickness, each cham-er will have in itself two or more galleries or steps.

Fig. 29 is a section of such a quarry worked on ree floors from the face of a hill. When the slate ck cannot be approached by levels driven in the irection shown on the figures, these may be driven t right angles, and enter the slate rock on the upper de of the slate bed, at point A, floor 3. Or if the hill opes rapidly on the north end of the section, the levels ay be driven on that side and the slate rock struck on s upper side. In this case the slate rock is supposed be approached by adit levels from the steep side of hill, along which, for a mile or more, the beds crop ut as shown on the section. Ordinarily, however, their ope or inclination is hardly so steep.

Usually, the first level driven is that on floor 1, which taken right across the slate bed to the overlying hard ck. From this point a level, or cross cut, is taken east d west, as shown on the ground-plan of the floor of e quarry, fig. 30, to a distance of forty yards on her side. Chambers 1 E and 1 W may now be com-nced and prepared a width of twenty yards each. A le saving may be effected by opening one of these chambers in the place of one of the pillars on either side of the level, but it is always well to have your way into and out of the quarry well secured. In opening a chamber the miners, who in such quarries always precede the quarrymen, begin by making a narrow opening of about three or four feet wide just under the hard rock, as shown at B in fig. 29. When they have done this for some distance forward, the quarrymen may begin to get blocks for slates, and their operations are facilitated by their making a gutter or trench, or loose end as it is called, along one side of the chamber. From this, which is deepened and carried forward as they proceed, they begin to quarry the rock in steps, as shown by the dotted lines in the section and plan, figs. 29 and 30.

The cost of the two latter operations are fairly chargeable to revenue account, the *levels* and cross cuts belong to that of capital.

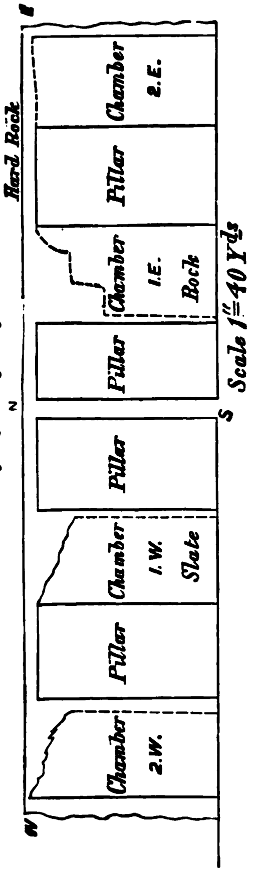


FIG. 30.
Ground Plan of Quarry Fig. 29.

The cost may be estimated as follows:—

	£	s.	d.
Driving North and South Level, 7 ft. × 7 ft. 65 yds. at 4*l.*	260	0	0
East cross cut, 40 yards at 4*l.*	160	0	0
West do. do.	160	0	0
Allow 200 square yards of unroofing at commencement of chambers, at 8*s.* per yard, 3 to 4 feet deep	80	0	0
Do. 100 yards of loose ends, at 5*s.*	25	0	0
Air pipes, fan, small water-wheel, or donkey-engine to drive do. for ventilation	100	0	0
For plant, &c., as per particulars in estimate of open quarry, say	1,200	0	0
	1,985	0	0
Add 10 per cent. contingencies, say	200	0	0
	£2,185	0	0

The produce of the two chambers when in full work should nearly equal that of the two galleries in the open quarry. From this point additional chambers may be developed and the lower floors, 2 and 3, commenced, as circumstances and means may determine.

Twenty yards is the ordinary width of a chamber, but it may vary more or less, according to the nature of the hard rock roof.

CHAPTER XV.

MANNER AND COST OF OPENING A SLA QUARRY—concluded.

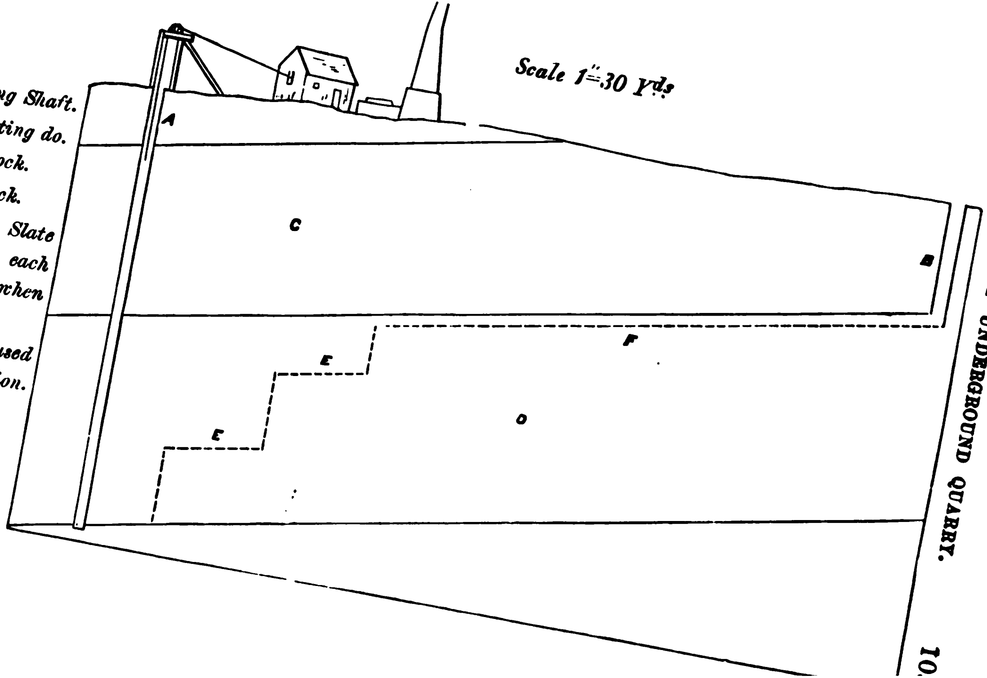
3. *Underground quarry worked by shafts.*

When the slate bed is inaccessible on a property means of adits, as in the last instance, and it is cover by a considerable thickness of overlying hard rock, is approached and worked by means of shafts like ordinary colliery, as shown in fig. 31, which represen a section of a quarry of this description.

The winding shaft A should be sunk, if possible, as to strike the bed at its deepest point on the propert and the quarry should eventually have another shaft for ventilation. The first thing to be done is of cours to sink the shaft A, which may be of the size of 16 fee × 9 feet. This size would admit of two ropes and cages. The ground plan, fig. 30, will also do for this quarry, and supposing the shaft A to strike the plan at the point N, levels would be driven forty yards either way as in that case. When these levels reach the side of the intended chambers nearest to the shaft, it would

SECTION OF UNDERGROUND QUARRY.

10.



A. *Winding Shaft.*
B. *Ventilating do.*
C. *Hard Rock.*
D. *Slate Rock.*
E. *Face of Slate Rock in each Chamber when in work.*
F. *Loose Top used for Ventilation.*

be necessary to open up to the overlying hard rock, in order that the unroofing may be commenced immediately under it. It is never safe to leave a portion of slate rock hanging from the hard rock above the chamber. As soon as possible a communication should be opened between the chambers in their upper portion, and the shaft B sunk so as to meet this communication. The ventilation of the quarry may afterwards be regulated as desired, and all directed towards this point.

I have assumed in the diagram that the shaft has to be sunk to a depth of 75 yards. The shaft is fitted with guides, wood gearing, and a pit head, as in a coal pit, but the whole work and gearing, from the heavy weights to be lifted, is of a more substantial character than that usually seen at collieries. Below is the approximate cost—

	£	s.	d
Shaft, 75 yards, 16 × 9, at 15*l.* per yard . .	1,125	0	0
Two levels, 40 yards each: 80 yards, at 4*l.* .	320	0	0
Opening up to hard rock in chamber 1 E, 40 yards, size of opening 9 feet × 5 feet, 5*l.* per yard	200	0	0
Do. for chamber 1 W	200	0	0
Cutting free side from this opening the full width of the chamber—after allowing for opening and level—38 yards × 17 yards: 646 yards, at 7*s.* per yard	226	2	
The same for the second chamber . . .	226	2	0
Sinking shaft B, 10 feet × 7 feet, 30 yards, at 7*l.* per yard	210	0	0
Forty yards of airways through pillars, to communicate with shaft B, at 4*l.* . . .	160	0	
One pair 25 h.p. horizontal engines, with boilers; fixing, engine house and chimney	2,750	0	0
Pit head, pit gear, cages, ropes, &c. . . .	280	0	0

	£	s.	d.
Pumps and gear, and fixing do.	210	0	0
Engine-man, two years	180	0	0
Stoker do.	130	0	0
Coal	260	0	0
Two banksmen at	240	0	0
Plant, management, &c., as in the other quarries	1,200	0	0
	7,917	0	0
Add 10 per cent. contingencies, say	800	0	0
	£8,717	0	0

The cost may be lessened by 160*l.* by reducing the size of the pillar at the bottom of the shaft to 20 yards instead of having it as a double pillar as provided for above. The tunnels and airways would be twenty yards shorter each. The engines, gearing, cages, &c., provided for above, would be equal to the working of the quarry for a much larger production than would be derived from the two chambers.

4. *Open quarry worked below the level of a flat country.*

To this class most of the quarries that are worked in the Nantlle district belong. Where there is not sufficient water-power at hand, a shaft has to be sunk with the aid of a steam-engine, driving cross tunnels as in the former cases, and from these stope or cut down a free side on what is to be the deepest side of the quarry. Or a long trench or loose face of sufficient length for a couple of slate bargains

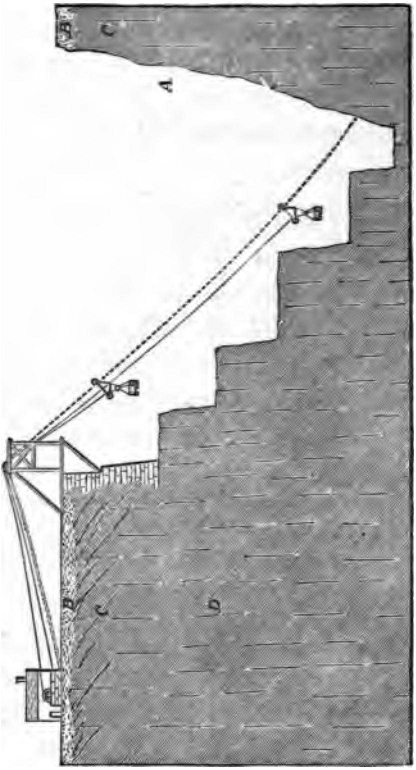


FIG. 32.

Section of Open Quarry below Level of Ground.

may be taken downwards to the depth desired. Pum ing will be necessary to keep the excavation dry, whic where practicable is done by water power, but steam has to be used very often. The winding of the slate blocks and rubbish is done by steam power by means

framework and winding gear like that shown in
32.

'ig. 32 represents a quarry of this kind. The first
; to be done is to remove the top drift B, and the
e top rock C. A shaft, or more generally a long
:h, is then taken down at A, which when down a
ient depth for a gallery is worked backward towards
inding machinery. When sufficient space is cleared
trench is continued downward to the depth of
her gallery, and so on as deep as the slate rock
nues, or it is practicable to work it. The cost
ring such a quarry into a profitable state under
arily favourable circumstances will be as follows:

	£	s.	d.
emoving top drift and waste rock, 40 yards × 50 × 8 deep—16,000 cubic yards—32,000 tons, at 1s.	1,600	0	0
roportion of cost of shaft, or trench, below line of drift and top rock, 40 yards × 15, at 10s. per yard	300	0	0
ne 25-h.p. semi-portable engine, with pumping gear attached	700	0	0
umps and fixing	100	0	0
hed	50	0	0
'inding gear	260	0	0
ngine-driver, two years	180	0	0
toker	130	0	0
ne banksman	120	0	0
oal	180	0	0
lant, management, &c., as in the other quarries	1,200	0	0
ontingencies, say	400	0	0
	£5,220	0	0

n estimating the relative value of each of the four kinds of quarries just described, the decided prefere must be given to the open quarry worked in galle on the hill-side, as being most easily and chea worked and developed. Next comes the open sunk quarry, which has the advantages of daylight. T chambered quarry No. 2, may be worked nearly cheaply as the last, but it labours under the disadva tage of darkness, in which the men are not able distinguish so readily between good and bad sla blocks, and in which they work in other respects at disadvantage. There is the danger also of falls of ro from the roof, which cannot be or is not examined readily and frequently as the chamber deepens to th width of the slate bed. Still it must not be forgotte that some of the best quarries in the Festiniog distri are worked on this plan; thin veins, of 25 to 40 yar in thickness, being generally purer than thick vein and yielding a larger proportion of finished slate the entire mass. In his report for 1877, T. Fannin Evans, Esq., Her Majesty's Inspector of Mines, f North Wales, very properly directs attention to th necessity of a more frequent examination of the roo of chambers than has hitherto been customary, and the need for more caution generally, in the working chambered quarries. The most expensive to develo is the No. 3 or underground quarry worked by shaft Happily the necessity for working by this method h not hitherto been great. Nor should a quarry on th plan be undertaken unless the slate rock is of sufficie thickness—twenty-five to thirty-five yards—and is proved to be of good quality. In many quarries there are combinations of these different methods. At Festiniog, for example, many of the quarries are worked partly in chambers and partly in galleries. Sometimes. as in the Llanberis and Nantlle districts, galleries above and excavations below the mean level of the surrounding country are worked. And in laying out a quarry, these probable combinations have to be taken into account.

CHAPTER XVI.

OUTSIDE ARRANGEMENTS, PLANT, AND ERECTIONS USUALLY REQUIRED BY ALL THE FOREGOING QUARRIES.

As the quarry is successfully approaching the stage of development indicated, attention will be demanded and justified to the outside arrangements for conducting the business of the quarry in the most effectual manner, and to the means whereby its produce may be most cheaply and quickly put in the market. We will begin with the last of these first. The gauge of the proposed tramway will be a point for first consideration. It may be set down as a rule that the narrower this is, consistently with its safe working, the more convenient will it be as it traverses the quarry, dressing sheds, and store yards. A two-feet gauge or, more strictly speaking, one foot eleven inches and a half between the rails, is the ordinary gauge in North Wales. This is the gauge of the well-known Festiniog Railway, over which is conveyed a large passenger as well as mineral traffic. The Croesor, the Gorsedda Junction, and the North Wales Narrow Gauge Railway, are of the same gauge, so that we may infer that the gauge is a safe and convenient one.

Most quarries are situated on high ground, and one the first requirements is one or more 'inclines' by ich the produce may be brought down to a con-ient level, from which to start the tramway. An line is sometimes constructed with a single pair ot ls having turnouts at convenient points. A second ld is one with three rails with similar turnouts. The st complete and least likely to get out of working ler, is one with a double line of rails from top to ttom, and this is the kind that, unless the quarry ner is greatly pinched for money, should be adopted. e following particulars of an incline just completed ll afford reliable data on which to calculate the cost an incline according to its length:—

	£	s.	d.
Length of incline 308 yards, moderate cuttings and embankments. Ground containing many large boulders. Gauge, 1 foot 11½ inches inside the rails. Cost of labour, inclusive of forming the earthworks, laying and ballasting the rails, and erecting masonry for drum and fixing the latter, all labour complete; double line of rails	145	0	0
Drum, 4 feet 6 inch barrel, iron rims, with break and all necessary gearing . .	50	0	0
320 sleepers, at 1*s.* 3*d.* each	20	0	0
Nine tons of 16-lb. bridge rails, at 6*l.* 12*s.* 6*d.*	59	12	6
4 cwt. spikes at 30*s.*	6	0	0
700 yards of 1-inch steel rope . . .	60	0	0
	£340	12	6

avier rails and better earthworks than those used l constructed in this case are desirable, so that we may e the incline as costing 30*s.* per yard.

I will next give the details of the cost of construc ing one mile of tramway on ordinary unenclosed mou tain land, earthworks not heavy, and no bridges, exce culverts for small rills. Single line of rails, gaug 1 foot 11½ inches between the rails:—

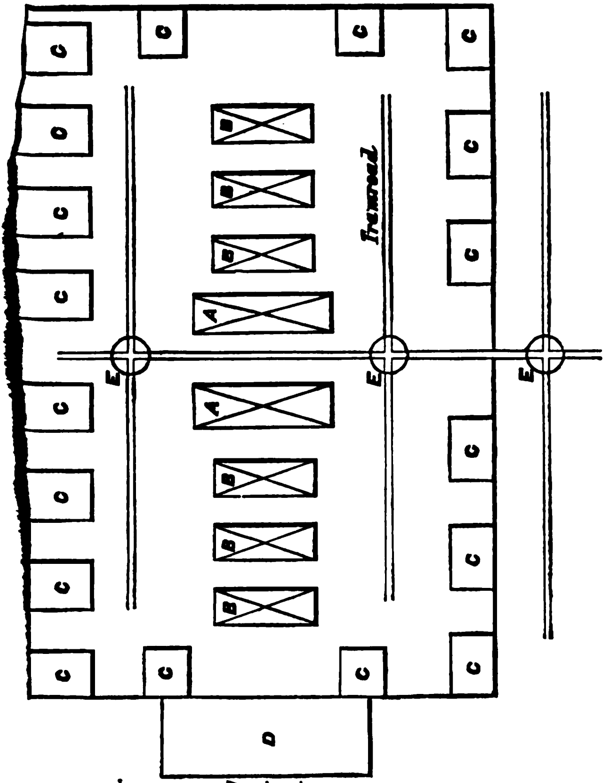
	£	*s.*	*d.*
24 tons of 16-lb. bridge rails, 6*l.* 12*s.* 6*d.*	159	4	0
1,800 sleepers, at 1*s.* 3*d.*	111	5	0
Spikes	15	0	0
Making road, laying rails, and ballasting, 2*s.* per yard (cost really under this sum)	176	0	0
	£461	9	0

It may therefore be safely assumed that under ordinary circumstances a tramway suitable for the p poses of a slate quarry may be constructed under 50 per mile.

In order to save time and slate blocks it w probably be decided to build a machine house, and erect machinery.

Fig. 33 may be taken as showing an ordinary usef size of house and arrangement of the machinery. Th cost may be estimated as follows:

	£	*s.*	*d.*
Erection of building, with water-wheel pit	650	0	0
Water-wheel, 30 feet diameter, 4 feet breast, with landers or troughs, and fixing do.	160	0	0
Six saw-tables, B B, at 40*l.* each	240	0	0
Two planing-tables for slabs, 85*l.*	190	0	0
Sixteen slate-dressing machines, 15*l.*	240	0	0
Shafting, straps, and gearing	350	0	0
Sundry small tools, sharpeners, &c.	75	0	0
Four turntables, 12*l.*	48	0	0
Rails and sleepers	25	0	0
	£1,978	0	0



A A. *Planing Machines for Slabs.*

B B. *Saw Tables.*

C C. *Places for Dressing Machines and Splitters.*

D. *Engine House or Water-wheel.*

E E. *Turn Tables.*

Scale 1″ = 30 *ft.*

The above will suffice for a large amount of work, but if slab-making with ridge-roll-making to any great extent is required, a separate machine house had better be subsequently provided for the purpose.

To turn the water-wheel water will of course be required, and it is generally necessary to store this in reservoirs during the time the machinery is not in use. For this purpose a sum of 500*l.* should in ordinary cases be ample.

An office will be required at the quarry, a workshop for carpenter and fitter—the smith's shop is already provided for. 260*l.* should suffice for these, together with two additional weigh-machines and sheds.

Then a crane, winzes, turntables, chains, hooks, ropes, &c. will be required, and we may set down 300*l.* for these.

Slate waggons will in most cases be required—the exceptions being where the quarry is close to an ordinary gauge railway, and where a public narrow-gauge railway finds rolling stock, slate waggons, such as are ordinarily used in Carnarvonshire—cost about 12*l.* each.

If the quarry is situated at some distance from a working population, the question of house accommodation will have to be considered. The building of cottages may be regarded as a separate undertaking, an ordinary building speculation. Still it may be a necessity for the due working of the quarry. At all events barrack accommodation will have to be provided in order that the men may remain on the ground from

Monday to Saturday. 500*l.* will go a long way in such rections, which are like simple cottages built in a row, ach of which will lodge from eight to ten men. The men usually pay about one shilling per week each for rent.

Let us now take an actual case, and sum up the foregoing outside expenses, allowing a little extra on some of the items.

	£	s.	d.
First incline, 500 yards, say	625	0	0
Second at 250 yards, say	312	10	0
One and a half miles of tramway, at 500*l.* per mile	750	0	0
Machine house and machinery . . .	2,000	0	0
Reservoir	400	0	0
Office, fitters' shop, weigh-machines and sheds	260	0	0
Cranes, winzes, turntables, points, &c. . .	300	0	0
Twelve slate waggons, 12*l.* each . . .	144	0	0
Barracks, &c.	500	0	0
Add for additional rails and sleepers . .	100	0	0
Carriage of materials, say 2½ per cent. . .	125	0	0
Add for contingencies 10 per cent., say .	530	0	0
	£6,046	10	0

It is difficult to say to what production of slates and slabs the foregoing plant would be equal, but I may say roughly that by adding slate waggons as required, and taken with the slates made by the galleries, it may be equal to a yield of 10,000 tons a year, possibly more. If the reader will add the sum above given to the amount required to develop each kind of quarry to the extent named in the former chapters, and add 3,000*l.* for urther developments in the quarry, and for working capital, he will gain a fair idea of the total cost, under the circumstances here supposed, of developing a slate quarry up to the production last named. How much of it is to be found at once as capital, or how much to be capitalised out of revenue, must be determined according to the circumstances of each case. The figures will stand thus:—

	£		
1. Cost of open quarry in galleries up to 8 bargains, as per particulars	2,592	10	0
Outside expenses	6,046	10	0
Add for development equal to 10,000 tons a year	3,000	0	0
	£11,639	0	0
2. Cost of chambered quarry, as particulars	2,185	0	0
Outside expenses	6,046	10	0
Further extensions as above	3,000	0	0
	£11,231	10	0
3. Cost of underground quarry, worked by shafts	8,717	0	0
Outside expenses	6,046	10	0
Further extensions	3,000	0	0
	£17,763	10	0
4. Cost of open quarry below surface	5,220	0	0
Outside expenses	6,046	10	0
Further extensions	3,000	0	0
	£14,266	10	0

CHAPTER XVII.

ON THE WORKING OF A SLATE QUARRY.

NEED hardly say that, in the first place, a suitable
anager must be found, for on his special knowledge
the particular slate bed of the neighbourhood gene-
lly, and on his experience in working and in the man-
gement of the men, the success of the enterprise wil
a very large extent depend.

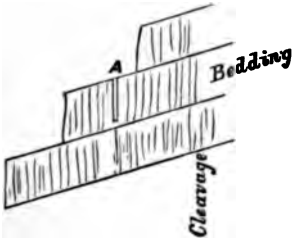
A gallery being ready, it is parcelled out into
bargains.' A 'bargain' consists of a portion of the
id gallery, varying from ten to fifteen yards in
readth, which is let each month to men who agree to
uarry the rock and to deliver the slates made by them
om it to the company at a given price. The number
men to a bargain is usually six, of whom two are
uarrymen and the remainder splitters and dressers.
enerally the company pay the trammers, who convey
e slate blocks from the quarry to the dressers, and
ho also remove the waste. The company finds the
ills, hammers, and other tools; the contractors pay-
g for the sharpening and repairs of the same. The
ter also pay for powder, fuze, and candles used by

them, the price of the whole, known as 'cost,' being deducted from the amount earned by the bargainers at the monthly settlement. There is a fixed scale of prices, by which the men are paid for the slates they make, which will be given in the chapter on the results of working. The variations in the quality of the rock, in each bargain, as that may be affected by 'posts,' crychs, 'bends,' sparry veins, faults, joints, and hardened rock, are provided for by a system of poundage. This consists in adding so much in the pound to the earnings of the men. It is seldom if ever now that the list price is sufficient pay in itself, so that the poundage begins generally with 7*s.* 6*d.* and reaches as high as 3*l.* The worse the quality of the rock, the larger the amount of poundage; and here it is that the qualifications of the manager, his knowledge of the rock, his observation of the way in which the men have worked, and his knowledge of their character are all tested, as the amount is fixed month by month. To make this matter of poundage plain, I may observe that if the earnings of a group of six men were, according to the list price, 16*l.* for the four weeks, 10*s.* poundage would increase it by one-half; or to 24*l.*, 20*s.* poundage would double the amount earned, and so on in proportion. Let us now follow the various processes undergone by the slate rock, from its position in its parent bed to its position as slates placed in a row ready for sale.

The first operation is that of quarrying the blocks.

The most favourable position of the rock for doing this is when the beds and the cleavage dip or incline towards the face of the quarry and to the man who is working, as in fig. 34. Great care is, however, necessary in keeping the top beds quarried well back, otherwise the danger of a fall from rocks in this position is great. The hole is made by an ordinary drill, which may be used by one man lifting it up and down as a jumper, or by two men, one turning it in the hole and the other striking it with a hammer. The particular method will depend upon the position of the hole and the preference of the men. At the Cambrian Quarries, Llanberis, the use of the Burleigh Rock Drill has been introduced with considerable success, the men, it is said, being willing to pay the same price to the owners of the quarry for drilling a hole with this machine that the hole would cost them if it were bored by hand, they being gainers by the saving of time effected by this method. The variety known as the 'Jumper Drill' is said to bore a hole 2 inches diameter and 10 feet deep, at the rate of 1 foot in seven minutes, the cost to the company being *5¾d.* per foot, including all expenses. The cost of the same if done by hand is from *8d.* to *9d.* per foot. The explosive generally preferred is the ordinary rock-blasting powder, the objection to litho-

FIG. 34.



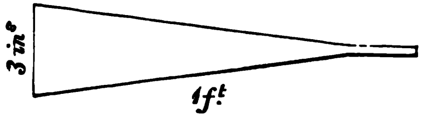
fracteur and similar combinations of nitroglycerine being the suddenness and force of the explosion, which shatters the rock. The force wanted is a dull heaving one, which will heave and displace the rock without unnecessarily breaking it. The skill of the quarryman is of course tested by his ability to take every possible advantage of slips, joints, and floors, and to make each hole do the greatest possible amount of work. The depth of the hole and the amount of powder used will depend largely upon the right occurrence and use of these natural helps. Where the slate rock is very solid and not intersected by joints, as in some of the Nantlle quarries, a hole 3 inches in diameter is made, by a drilling machine known as Dixon's, to a good depth, and a charge of from fifteen to twenty pounds of powder inserted. This has the effect of bringing down a large body of rock, broken into good sized blocks. With small holes and charges the rock would be shattered to fragments. Where a large quantity of hard or waste rock has to be removed, it is common to use large charges of powder with large holes. If the mass be very great, a small chamber is made in the rock, and the whole mass blown down and shattered bodily. This is practised in some of the Llanberis quarries. In driving tunnels also nitroglycerine, dynamite, and other powerful explosives are often used.

The blocks being obtained are now broken into convenient sizes to be sent to the slate-makers. Here again the judgment and skill of the quarryman are sted. It is to his advantage as well as to that of the mpany that as many slates as possible be got out f the block, with as little waste as can be helped. arge blocks are constantly crossed by ‘crychs,’ bends, amps, spar veins, and the like disfigurements and ndrances.

Taking the block, he has to consider how in tting it up he may bring these to the ends of the tes to be made, that they may be cut off in the essing. If the block is wide, he splits it lengthwise, as to suit two slates of the same or different widths. does this by making a notch at the end, and iving in a wedge along the line on which he wants e block to break, or by drilling a hole somewhere on at line; and placing in this two iron wedges, he ives a third down between them, when the block ually splits in the direction required. This opera n is known as ‘pillaring,’ and the quarryman is often led by a slight natural cross cleavage, like that eady referred to, which is locally known as ‘pillar- g.’ If the blocks are too long, he crosscuts them in similar manner, having first split them up into blocks about 2 inches thick. It is in performing these erations that he avoids the blemishes in the block eady enumerated. The reduced blocks are now ded into waggons and taken to the dressing sheds, ich are little huts rudely built of slate rock, and ced in a row at a convenient place on the outside of h gallery or floor of the quarry. Between these huts runs the tramroad by which the blocks are brought and the slates and waste taken away. Supposing a hut to contain a splitter and dresser, the process is as follows:—The splitter is seated on a block, raised but little above the level of the floor; the blocks are placed on his left hand; he has a wooden mallet bound with iron—for the blow from wood is better adapted for the splitting of the slates than one from steel. He has three or four splitters, fig. 35, which are thin chisels with a broad fine edge. They range from 10 to 15 inches in length, and the broad end is from 2 to 3½ inches wide. He takes a block, and having viewed it to see what condition it is in, he places it against his left thigh, with the smoothest and straightest end uppermost. He places his splitter in the centre, and makes two or three cuts all in a line; the centre one of these he sends further into the block, which begins to split; he inserts a second splitter, and works the two backwards and forwards, the split extending down the block, and dividing it in two. This process is repeated until he gets the slates of sufficient thinness. Each time, however, greater care is required, and if the material be fractious or crossed by bends, he has to

FIG. 35.

Splitter.



sert another splitter at the side, and humour the lock until he carries the split right through. He laces the irregular shaped slates on his right hand, nd they are ready to be squared into shape by the resser.

The dresser sits with a carrier before him, fig. 36, hich is a wooden bench, on which is fixed a steel nife or frame. In his right hand is a long knife or esser, fig. 37. He places the slate block on the rier, and trims one straight side and one straight l at right angles to each other. He now takes a

FIG. 36.
Stool and Traverse.

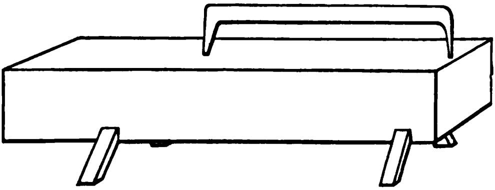
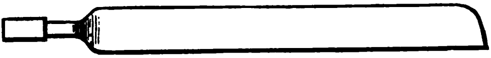
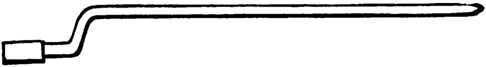


FIG. 37.
Knife.



Side.

FIG. 38.
Knife.

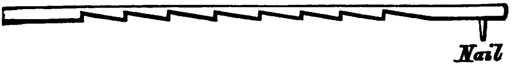


Top.

notched stick, fig. 39, with a spike on the end, and seeing, from long use, at once what sized slate the block will make, he places one of the notches, which are cut to suit the various sized slates, against the straight side, and marks the opposite side with the spike. He does the same thing for the length of the slate, and squaring the block to these marks, the result is a finished slate. If the slate be of first quality he places it with the slate on his right hand, according to its size. If of second quality, among those on his left. If of third, with another heap, but the proportion of thirds in an ordinary quarry is small. The slates are now ready to be stacked in the pile belonging to the bargain, to be duly examined, counted, and paid for according to their value.

FIG. 39.

Stick.



Attached to a bargain there are usually one or more 'rubblers,' who often are the sons of the bargainers, and are learning their trade. They select what slate blocks they can from the 'rubble' or waste rejected by the quarrymen, and make from these what slates they can, at the list price, and a special poundage agreed upon. See the table of three bargains from the Festiniog district, given in Chapter XIX.

CHAPTER XVIII.

MACHINERY COMMONLY USED IN SLATE QUARRIES.—SLAB MAKING.

quarries where machinery is used, the processes un-
gone by the block from the time it is split into ap-
ximate widths, and into thicknesses of two inches,
different from the processes just described from that
int. Some rocks will not crosscut well, jagged edges
ing left, which are very unfavourable for the work of
e splitter. The smoother the edge of the block the
tter for his work. Then it is obvious that there
ust be a good deal of waste of the rock in cross-
tting, which might be obviated if the block could be
t smoothly across. This smooth edge is gained, and
e waste prevented, by the use of the sawing machine.

The ordinary sawing machine is but little different
m those used for sawing timber. It is driven by
nd, pulley, and shafting moved by the water-wheel or
am-engine, as the case may be. The power required
y be estimated by taking one-horse power as equal to
o saw-tables.

The blocks are brought into the machine house, where they are taken and placed three or four deep on the saw table, where they are speedily cut across and handed to the dresser of the bargain to which they belong. The attendant on the sawing machine has of course to use the same discrimination in cutting the blocks across as the crosscutter would in the quarry. There is a sawing machine used in some of the Llanberis and Festiniog quarries, known as Hunter's, which has circular teeth, and which, although it wastes rather more rock, is better adapted for cutting hard rock, and it is now much used for the purpose. Then there is a sawing machine by which flags are cut up into square lengths, 2½ to 3 inches square, for the purpose of being worked up into crest, rolls for roops.

In a machine house the splitters are seated along the walls close to the dressers, as shown in fig. *33.* Mr. Hughes, of Aberllefeni Quarry, Corris, has invented a slate-splitting machine, but it is doubtful if any machine can take the place of the intelligent skill and humouring of the material which the best splitters can only gain by long practice. Mr. Hughes' machine can be seen in work at his quarry. The dresser is a machine with a rising and falling knife after the fashion of a guillotine, or rather shears. There are two kinds chiefly in use—Francis', which is worked either by a treadle or by machinery, the cutter being assisted in rising by a spring; and Mathews', worked by machinery, in which two knives are fixed opposite each other, their ends being fixed in two wheels about a yard part. The knives are fixed somewhat diagonally, as he knives in a straw-cutter, and as with the wheels they evolve, they cut the slate in the most perfect manner.

The notched wood is fixed by the side of the sing and falling knife, and the dresser cautiously laces his slate in this, when the knife descending cuts to size. The planing machine is constructed on the rinciple of those used in planing iron. They are ade of various sizes up to those which can take a slab rge enough for a billiard table. The ridge roll achine is a useful contrivance, by which the square ngths of slab before referred to are gradually rounded, nd a notch formed on the under side, into which the opmost slates of the roof, made specially for the purose, may be inserted and held together. The saw harpener is a useful contrivance, for the saws used equire sharpening, on an average, about twice a day.

Among the outside contrivances at a slate quarry, ference may be made to the water balance. This mple but useful appliance consists of an iron tank xed upon wheels, and placed upon an incline. When lled with water it is able by its greater weight bring up slate blocks, or whatever is required, and hen at the bottom, the water may speedily be disharged. Almost every quarry manager has his own daptations of this contrivance, some of them very ingenious. Where the volume of water available on a slate property is not great, but the fall is considerable, turbine may take the place of the water-wheel. An example of the effectual application of this method of water-power may be seen in operation at the Rhiw-goch Quarry, in Dolwyddelen. Where a water-wheel has to be placed at a considerable distance from a quarry that requires to be drained by pumping, force pumps are sometimes worked by means of an endless wire rope, which is carried, by means of small pulleys fixed on posts, from the driving pulley on the water-wheel, to a pulley fitted on a double-cranked axle, to which the pump rods are attached. The contrivance has this drawback: in winter time the rope gets wet with rain at the beginning of the night, frost succeeds, making the rope as slippery as glass, in which condition it slips around the pump pulley without doing its work.

The manufacture of slabs.

Among the outgrowths of the slate trade in recent years is that of the manufacture of slabs, which is a most valuable addition to the sources of income in many slate quarries. In all quarries there are, as we have seen, portions of the rock that have been hardened by heat, or which are traversed by hard bands, or the material of which has originally had hardly the proportion of fine loose material—silica, which seems necessary for the perfection of cleavage, or rock, which from other causes is not adapted for the manufacture of slates.

Blocks of such rock can now be taken to the machine house, and planed down to the requisite thickness by the planing machines, and cut to size by the sawing machines, and may further be ground, scoured, polished, and otherwise made ready for manufacture into various architectural and domestic uses. The trade seems originally to have sprung up in Ireland, for we have seen how the slabs of Killaloe were formerly exported to this country. Among the uses to which the material is applied, I may enumerate the following:—

Slabs planed only on one surface and squared at he edges for the flooring of barns and farm buildings enerally.

Slabs planed and squared for the better class of oring, as well as for hearthstones, doorsteps, and e like.

Slabs planed and cut to size and fitted for public inals, sometimes coated with enamel.

Slabs planed for closets and sanitary purposes gene-lly in camps, barracks, and public institutions.

Slabs planed, cut to size, and dressed for chimney-ieces, which are now beautifully polished, richly orna-ented, and enamelled.

Slabs made into stalls and feeding-troughs for attle in shippons and farmyards, which, from their cleanliness, are likely to supersede the old wooden fittings.

Cisterns for water, oils, and acids, building stones, and where hard enough setts for side pavements.

Ridge rolls and crests, tombstones.

The manufacture may be considered in its infancy, and the purposes for which the material will be used will in all probability be largely increased. The men are usually paid so much per ton for the finished slabs. This varies somewhat, but the average price may be taken at 8*s.* per ton. The slabs of the Corris district, line 3 D, and of the Llangollen district, line 4, admit of being most readily worked. Those of the former place are considered the best for taking enamel, and large quantities are sent to Bristol and London for that purpose.

The manufacture of slabs into various articles is usually a distinct undertaking from that of the quarry enterprise. In and near the towns of Bangor, Carnarvon, Portmadoc, and Llangollen, there are manufactories for this purpose. The quarry owners generally sell the squared and planed slabs to the proprietors of these establishments, as well as to builders and masons, although in some cases, as at Llangollen, the slab mill is worked by the owners of the quarry.

The two following lists will between them give pretty full particulars of the prices of the slabs as adapted to various uses, subject to an advance since the lists were issued of fifteen per cent. :—

1874.

SLABS.

Lotted Slabs of Promiscuous Lengths and Breadths.

	Purple Slabs planed, per ton £	s.	d.
Lot 1, between 3 feet and 7 feet long, and from 2 feet to 4 feet wide—			
½ inch thick	3	15	0
¾ "	3	5	0
1 "	2	15	0
1¼ "	2	9	0
1½ "	2	4	0
1¾ "	2	2	0
2 inches and upwards	2	0	0
Lot 2, between 7 feet and 8 feet 6 inches long, and 2 feet 6 inches to 4 feet wide—			
1 inch thick	3	8	0
1¼ "	3	3	0
1½ "	2	17	0
1¾ "	2	15	0
2 inches and upwards	2	9	0
Lot 3, cut in courses for paving to order, from 1 inch thick and upwards, from 1 foot 6 inches to 3 feet long, and from 1 foot to 2 feet wide, planed	1	15	0

Of 20 cwts. to the ton, and 112 lbs. to the cwt.

Planed slabs of larger sizes than lots 1 and 2, 10*s.* per ton extra.

Planed slabs prepared to particular dimensions to order, 10*s.* per ton above the price of slabs of similar sizes in lots 1 and 2.

N.B.—About 150 feet superficial of 1-inch slab is computed to weigh a ton.

SLATE RIDGES.

No. 1 Roll, 3 in. diameter, sides unplaned, 6 in. wide and ¼ in. thick	8*d.* per foot.
No. 2 Roll, 2½ in. diameter, sides unplaned, 6 in. wide and ¼ in. thick	7*d.* "
No. 3 Roll, 2 in. diameter, sides unplaned, 6 in. wide and ¼ in. thick	6*d.* "
No. 4 Roll, 1¾ in. diameter, sides unplaned, 6 in. wide and ¼ in. thick	5*d.* "

The roll and plates are sometimes sold at 6*l.* per ton.

CISTERNS.

	s.	d.	
Not less than 5 ft. and under 15 ft. cubic contents	2	3	per foot
„ 10 ft. „ 20 ft. „	2	1	„
„ 20 ft. „ 25 ft. „	1	11	„
„ 25 ft. „ 30 ft. „	1	9	„
„ 30 ft. „ 60 ft. „	1	8	„
„ 60 ft. and upwards „	1	6	„

An additional charge will be made for extra thickness an work.

1874.

SLABS.

As Squared at the Quarries (Random Sizes).

1 to 1½ inches in thickness	3*d.*	per foot.
2 inches „	4½*d.*	„
2 to 3 inches „	6*d.*	„

SAWN EDGES.

Lotted flags, of promiscuous lengths and breadths, as under:—

Lot 1—1 in. in thickness (not exceeding 10 ft. superficial)	4½*d.*	per foot.
1½ in. in thickness (not exceeding 10 ft. superficial)	6*d.*	„
2 in. in thickness (not exceeding 10 ft. superficial)	7½*d.*	„
2½ in. in thickness (not exceeding 10 ft. superficial)	9½*d.*	„
3 in. in thickness (not exceeding 10 ft. superficial)	10½*d.*	„
Lot 2—1 in. in thickness (above 10 ft. and not exceeding 18 ft. superficial)	5½*d.*	„
1½ in. in thickness (above 10 ft. and not exceeding 18 ft. superficial)	7*d.*	„
2 in. in thickness (above 10 ft. and not exceeding 18 ft. superficial)	8½*d.*	„
2½ in. in thickness (above 10 ft. and not exceeding 18 ft. superficial)	10½*d.*	„
3 in. in thickness (above 10 ft. and not exceeding 18 ft. superficial)	11½*d.*	„

Slabs of larger sizes to order, 1*d.* per foot extra, or per specia contract.

Planing, 1*d.* per foot each side. Polishing, 1*d.* per foot each side.

Mangers, from 2*s.* 6*d.* to 3*s.* 6*d.* per foot lineal.

Cisterns of ordinary square dimensions, under 100 gals., 4*d.* per gal.

Cisterns, above 100 and under 500 gals., 3½*d.*

Cisterns, larger sizes, as per agreement.

Tombstones, from 4*l.* 10*s.* to 8*l.* each.

Headstones, 2 in. thick, 10½*d.* per foot.

Gravestones, 3 inches thick, 13*d.* per foot.

Chimney-pieces, from 5*s.* each upwards.

Do. for kitchens, from 14*s.* each upwards.

Skirting, sawn and planed, 6 in. wide, 5½*d.* per foot lineal.
Do. do. 9 in. „ 6½*d.* „

Edging for gardens, 1*d.* per foot lineal.
Ditto, sawn ends, 2*d.* „
Roll and Ridge, 7½*d.* „

CHAPTER XIX.

RESULTS OF WORKING.

In this chapter I propose to give the actual results attained by bargains of various kinds, worked in four ordinary successful quarries. From these particulars we can get at the actual gross profit per ton on the slates made, and we shall then, by adding the various working charges, royalty, and trade expenses, be able to arrive at the actual average net profit per ton pertaining to the examples given. I take slates only, but the profit on slabs may be safely assumed as equal to that on slates.

I will first give the particulars, for one month, of a bargain in a quarry in the Llangollen district. The first column gives the names by which slates are called, and which names are supposed to have been given by General Warburton, who owned the Penrhyn Slate Quarries about a hundred years ago. The second gives the sizes of the slates; the third, the number of eac size made by the men in the four weeks; the fourt the list price paid for making, which, with slight vari tions, will be found to be the same in the subseque tables; the fifth contains the amount paid for the quantity of slates made; the sixth, the value of the slates at seconds; the seventh, the list price in July 1876, only subject to an advance of 7½ per cent., not allowed in these calculations; the eighth, the weight of all best; the ninth, the weight of all seconds; the tenth, the average weight; the eleventh, the computed weight per thousand of 1,200 of bests and seconds; the twelfth contains sundry remarks, explanations, and deductions. The whole table will, I hope, be found very useful. The month for which it is taken was a good one. The average produce of the same bargain for five months, including loss of time by men and all stoppages, was, as will be seen by a table of the same bargain, given in the next chapter, 38 tons per month. It should also be observed that both the weight and value of the slates per thousand were lessened by the large quantity of 'randoms' made.

Particulars of a Slate Bargain in

JULY

Names of slates	Sizes	Quantity made per thousand of 1,200	Price for making one hundred of 126	Amount for making slates	Value at Seconds price	List Price of 2nd quality, July 1876
	inches		s. d.	£ s. d.	£ s. d.	£ s. d.
Princesses . .	24 × 14	860	2 9	1 3 4½	10 12 6	12 10 0
Duchesses . .	24 × 12	2,560	2 6	3 3 9	28 1 6	11 0 0
Do. small .	22 × 12	1,200	2 4	1 7 11½	11 11 0	9 12 6
Marchionesses .	22 × 11	1,660	2 3	1 17 1½	14 0 6	8 10 0
Do.	20 × 12	500	2 3	0 11 3	4 5 0	8 10 0
Countesses . .	20 × 10	3,760	2 0	3 15 0	28 2 6	7 10 0
Do. wide . .	18 × 10	1,900	1 6	1 8 6	11 12 9	6 2 6
Viscountesses .	18 × 9	1,600	1 3	1 0 0	8 8 0	5 5 0
Ladies . . .	16 × 10	1,400	1 3	0 17 6	7 7 0	5 5 0
Do.	16 × 8	2,260	1 0	1 2 6	5 0 0	4 0 0
Small do. . .	14 × 12	100	1 3	0 1 3	0 8 9	4 7 6
Do. . . .	14 × 10	900	1 0	0 9 0	3 16 6	4 5 0
Do. . . .	14 × 8	960	0 9	0 7 1½	2 19 4	3 2 6
Do. . . .	14 × 7	1,000	0 7½	0 6 3	2 12 6	2 12 6
Doubles . . .	13 × 8	1,000	0 6	0 6 3	2 12 6	2 12 6
Do. . . .	13 × 7	60	0 6	0 0 3	0 2 3	2 7 6
Do. . . .	12 × 10	700	0 9	0 5 3	1 15 0	2 10 0
			Per M. of 1,260			
Randoms . .		4,760	4 0	0 19 0	4 15 0	1 0 0
		26,180		18 15 1	145 9 7	

	£ s. d.
Add poundage at 10*s*.	9 7 6
Two trammers, 23 days each at 3*s*. 8*d*. .	8 8 8
Total cost in quarry	36 11 3

angollen District, North Wales.

ght, Best	Weight, if all Seconds			Average weight			Computed weight per thousand of 1,200		Explanatory remarks
							Best	Seconds	
Qrs.	Tons	Cwts.	Qrs.	Tons	Cwts.	Qrs.	Cwt.	Cwt.	
2	3	16	2	3	8	0	70	90	No. of men on bargain— Quarrymen, splitters, and dressers . . 6 Trammers conveying blocks and waste . 2 No. of days worked by each man . . 23 Proportions of best slate to second quality, two-thirds. Weight of 26,180 slates, 54 tons 3 qrs. Average weight per thousand of the whole production, a little over two tons, or the weight of 20 × 10 Average value per thousand, leaving out fraction, *5l.* 11*s.* 6*d.* or price of 18 × 9 best, adding 7½ per cent. Average value per ton . . . . 2 13 8 Add 7½ per cent.. 0 2 4 £2 16 0 Cost per ton in quarry . . . 0 13 4 Gross profit per ton 2 2 8
0	10	4	0	8	18	2	60	80	
0	4	4	0	3	15	0	55	70	
2	4	19	0	4	10	3	50	60	
2	1	10	0	1	8	3	50	60	
0	9	7	2	8	8	3	40	50	
2	4	9	1	3	19	1½	36	47	
2	3	7	1	2	17	1½	31	42	
2	2	18	3	2	11	0½	31	42	
1	3	14	1	3	5	1	25	33	
0	0	3	3	0	3	1½	30	37½	
1	1	11	2	1	7	3½	27	35	
3	1	8	2	1	6	0½	25	30	
0	1	5	0	1	2	2	20	25	
0	1	5	0	1	2	2	20	25	
3	0	1	0	0	0	3½	18	21	
0	0	18	2	0	17	1	23	27	
0	6	0	0	6	0	0			
0	59	18	3	54	0	3½			

The next table of particulars is from the Festiniog district. It comprises an underground bargain and an open double bargain for May 1877, and an open bargain for May 1874. It also comprises various poundages, all of which are higher than that paid in the last table. It has not been thought necessary to repeat some of the details given in that table, but instead we have the total amount of rock removed in each case, the weight of the blocks sent to the machine-house, and the actual percentage of finished produce derived from the rock removed. The table, therefore, is of special value. The following is a summary of the value, cost, and gross profit from these bargains:—

	No. 1.			No. 2.			No. 3.		
	Ton	Cwts.	Qrs.	Ton	Cwts.	Qrs.	Ton	Cwts.	Qrs.
Average weight per thousand	2	2	0	2	5	0	2	5	0
							(May 1874).		
	£	s.	d.	£	s.	d.	£	s.	d.
Average value per ton, as per schedule	4	0	2	4	2	7	2	17	9
Cost in quarry	1	12	0	1	2	0	0	18	4
Gross profit in quarry	£2	8	2	£3	0	7	£1	19	5

Taking the three bargains together, we have the averages as follows:—

Average weight per thousand, 2 tons 4 cwts., or the weight of slates, 20 × 10 best.

	£	s.	d.
Average value per ton, reckoning No. 2, which is a double bargain, as two bargains, or the value at present prices of 20 × 10 slates, second quality	3	15	9
Average cost in quarry, taking No. 2 as two bargains	1	3	7
Average gross profit in quarry	£2	12	2

Particulars of Bargains in the Festiniog District.

Make		No. 1. Underground Bargain for 4 weeks ending May 19, 1877	No. 2. Open Bargain for 4 weeks ending May 19, 1877	No. 3. Open Bargain for 4 weeks ending May 30, 1874
	Inches.	No. of Slates	No. of Slates	No. of Slates
1st Quality .	24 × 14	2,160	2,160	2,900
" .	24 × 12	1,400	7,300	1,700
" .	22 × 12	360	760	700
" .	22 × 11	460	2,660	1,000
" .	20 × 10	4,160	13,660	3,900
" .	18 × 10	560	1,800	1,460
" .	18 × 9	1,200	2,860	960
" .	16 × 10	300	1,100	760
" .	16 × 8	1,600	3,960	1,300
" .	14 × 12	60	100	200
" .	14 × 8	800	1,400	760
" .	14 × 7	500	2,060	560
" .	13 × 10	460	460	1,060
" .	13 × 7	300	600	300
" .	10 × 8	1,100	860	500
2nd Quality .	24 × 14	200	160	500
" .	24 × 12	160	360	460
" .	22 × 12	60	60	300
" .	22 × 11	60	260	260
" .	20 × 10	500	900	1,400
" .	18 × 10	60	260	500
" .	18 × 9	260	500	400
" .	16 × 10	60	160	200
" .	16 × 8	200	660	700
" .	14 × 8	200	200	300
" .	14 × 7	60	200	200
" .	13 × 10	100	—	360
		16,340	44,460	26,640
Poundage to Bargain takers		30*s.*	25*s.*	20*s.*
Poundage to Rubblers		20*s.*	40*s.*	25*s.*
Average poundage . .		29*s.* 5¾*d.*	25*s.* 11¾*d.*	21*s.* 3¼*d.*

Particulars of Bargains in the Festiniog Distri

CONTINUED.

Particulars.	No. 1. Underground Bargain for 4 weeks ending May 19, 1877	No. 2. Open Bargain for 4 weeks ending May 19, 1877	No. 3. Open Barg for 4 weeks' en May 30, 18
Men employed—			
Bargain takers	3 rock men 1 slate maker	4 rock men 4 slate makers	1 rock m 2 slate m
Men paid by bargain takers at day wages	2 slate makers	1 rock man 4 slate makers	1 rock m 1 slate m
Rubblers earning what they can after men have selected blocks	1 boy . . .	2 men . .	3 men
Filling and tipping, paid by quarry owner	2 labourers .	2 labourers .	1 laboure
Total	9	17	9
	Tons Cwts. Qrs.	Tons Cwts. Qrs.	Tons Cwts.
Total rock moved	247 0 0	663 0 0	344 0
Of which there were blocks to mill	141 0 0	314 0 0	187 0
And slates made	34 17 3	100 9 1	51 6
Yield per cent. from rock moved	14·13	15·15	14·92
	£ s. d.	£ s. d.	£ s.
Average value per ton at current prices	4 0 2½	4 2 7	2 17
Cost of slate making at standard prices	14 7 10	42 18 5	19 17 1
Poundage on do.	21 4 7	55 14 5	21 3
Sinking; cutting bone and open side	9 10 0		
Filling, tipping, and pumping	11 0 2	12 8 7	4 18
	56 2 7	111 1 5	45 19

ext table is from the Nantlle district. It also full table, and its special features consist in g the proportion of first, second, and third of slates made in the quarry, and also the earnings per man, when to the list price value ates made the poundage is added. When we ed the poundage and wages of trammers to the for slate making, as per list price, the total he production of each bargain will be as below :

	No. 1.	No. 2.	No. 3.
	£ s. d.	£ s. d.	£ s. d.
te making	29 9 0	14 17 1	19 11 1
	26 0 4	14 17 1	39 2 2
mers, allowing to each and each bargain, day present	9 4 0	9 4 0	9 4 0
rgain in quarry	£64 13 4	£38 18 2	£67 17 3
ber of slates	23,175	11,400	17,750
	Tons Cwts. Qrs.	Tons Cwts. Qrs.	Tons Cwts. Qrs.
l weight	76 0 0	49 4 0	44 15 0
	£ s. d.	£ s. d.	£ s. d.
l value	269 9 0	132 3 6	140 9 6
	Tons Cwts. Qrs.	Tons Cwts. Qrs.	Tons Cwts. Qrs.
weight per d	3 0 0	4 5 0	2 10 0
	£ s. d.	£ s. d.	£ s. d.
ton	3 10 9	2 13 10	3 7 0
ton in quarry	0 17 1½	0 15 11	1 10 10
fit in quarry	£2 13 7¼	£1 17 9	£1 16 2
	£ s. d.	£ s. d.	£ s. d.
r thousand	10 10 3	11 8 9	8 12 6
slates	22 x 11	22 x 12	20 x 10

Particulars of Three Slate Bargains in Quarry in the Nantlle District

(Four Weeks' Accounts).

QUANTITY OF SLATES MADE IN THREE BARGAINS IN FULL WORK ON POUNDAGE ALONE, WITH COST OF SAME TO THE COMPANY.

Sizes	Bargain, at 17*s.* 6*d.* poundage			Cost of making		Cost	Bargain at 20*s.* poundage			Cost of making	Bargain at 40*s.* poundage			Cost of making
	1sts	2nds	3rds	1st & 2nd	3rds		1sts	2nds	3rds		1sts	2nds	3rds	
inches.				*s.* *d.*	*s.* *d.*	£ *s.* *d.*				£ *s.* *d.*				£ s. *d.*
30 × 16	600	—	—	40 0	—		300	—	—		450	—	—	
26 × 16	3,700	—	—	35 0	—		1,900	—	—		1,300	—	—	
26 × 13	2,450	—	—	30 0	—		1,400	—	—		1,450	—	—	
24 × 14	1,900	150	100	27 6	22 6		450	150	250		1,000	50	50	
24 × 13	800	—	—	26 8	—		250	—	—		500	—	—	
24 × 12	1,550	200	50	25 0	20 0		800	50	200		1,300	150	100	
22 × 12	2,650	150	50	24 2	18 4		700	150	100		1,250	100	100	
22 × 11	1,400	150	50	23 4	16 8		650	100	100		1,100	100	100	
20 × 12	2,050	—	—	22 6	21 8		750	—	—		1,000			
20 × 11	400	—	—	22 6	21 8		150	—	—		500			
20 × 10	1,050	200	100	20 0	15 0		600	250	200		1,400	250	200	
18 × 12	600	—	—	20 0	15 0		500	—	—		450			
18 × 10	200	5	50	15 0	12 6		300	100	50		650	100	50	

14 × 12	—	—	—	8 4										
14 × 10	150	—	—	8 4	7 6		50	—	—		200			
14 × 8	—	—	—	7 6	6 0						400			
13 × 10	—	—	—	6 8										
14 × 7	—	—	—	6 0										
13 × 8	—	—	—	6 8										
13 × 7	—	—	—	5 0										
12 × 10	—	—	—	6 8										
12 × 8	—	—	—	5 0										
12 × 6	—	—	—	3 4										
12 × 5	—	—	—	2 6										
Ton slates (8 cwt. or 70 slates)				5 0	per ton									
	21,720	855	600			29 9 0	9,500	850	1,050	14 17 1	16,150	800	800	19 11 1

2 men on rock } worked 127½ days.
4 slate-makers }
Average wages per day, 8*s.* 7*d.*
No allowance for bad rock.
The Company carry all the waste at their own cost.

2 men on rock } worked 132½ days.
4 slate-makers }
Average wages per day, 4*s.* 4*d.*
No allowance.
The Company carry all the waste.

2 men on rock } worked 133½ days.
4 slate-makers }
Average wages per day, 8*s.* 9*d.*
No allowance.
The Company carry all waste.

Two trammers are generally for each bargain. The four men slate-making include splitters, dressers, and sawing, or attending the sawing of blocks.

Particulars of a Quarry in the Festiniog Distric

OCTOBER 1867.

Sizes	Number made	Price per thousand of 1,200		Amount		
Inches.		*s.*	*d.*	£	*s.*	
26 × 15	5,200	30	0	4	16	
24 × 14	5,760	27	6	7	18	
24 × 12	5,300	25	0	6	12	
22 × 12	1,160	23	9	1	7	
22 × 11	2,100	21	8	2	5	
20 × 10	4,500	20	0	4	10	
18 × 10	460	17	6	0	7	10
18 × 9	360	15	0	0	5	3
16 × 10	100	15	0	0	1	3
16 × 8	100	8	4		0	10
14 × 12	100	15	0		1	6
2nd Class.						
24 × 14	100	21	8	0	2	2
24 × 12	100	20	0	0	2	0
20 × 10	100	17	6	0	1	9
Fancy slates . .	760	—		1	0	7
	26,200			29	12	6

	£	*s.*	*d.*
Amount	29	12	6
Poundage at 7*s.* 6*d.*	11	2	0
Four labourers, 23 days each at 3*s.* 9*d.* . . .	17	5	0
	£57	19	6

Weight of slates, 69 tons; estimated value, 207*l.* 2*s.* 6*d.*
Weight of slates per thousand, 2 tons 13 cwt., equal to 22 × 11.
Price per thousand, 8*l.*: equal to 22 × 12, best, prices of 1867.

Value per ton	3	0	0
Cost per ton in quarry	0	16	9
Gross profit in quarry	£2	3	3

CHAPTER XX.

SUMMARY OF WORKING RESULTS—NET PROFITS AND PRICE LISTS.

E have now before us the particulars of the working nine different bargains, contained in four quarries, tuated a good distance from each other. One of he bargains is an underground one. The poundage aries from 7*s.* 6*d.* to 40*s.*, and without multiplying imilar examples, as I might do, I think we may conider that these will afford us an accurate idea of the esults of ordinary bargains in ordinary quarries. For he sake of comparison, however, I append to this hapter two additional tables; the first of which shows he average monthly production of five months' workng of the bargain in the slate quarry in the Llangollen istrict. The second shows the details of the producion for one month just past of two open bargains, orked in the Old and New Veins respectively, in a rge quarry in the Festiniog district, at 50*s.* poundage. et us now summarise and average the results shown the working of these nine different bargains. I will bulate them as follows:—

	Tons	Cwts.	Qrs.
Average production per bargain	57	10	0
Average weight per thousand of 1,200 . .	2	12	0
Equal to slates 22 × 11 best.			
	£	s.	d.
Average value per ton	3	7	7
Average cost per ton in the quarry . .	1	0	11
Average gross profit in quarry . . .	2	6	8

It should be observed with respect to the average production of the foregoing bargains that they were in full work, but that in estimating the produce of a quarry containing a number of bargains allowance must be made for loss of time, stoppages, and bargains temporarily unproductive. Thirty-five tons per bargain would be a safer figure in estimating the produce of an ordinary quarry. In preparing such estimates for young quarries I seldom place the production higher than thirty tons, but this is below the average.

I will now proceed to enumerate the expenses of management, traffic, and royalty, which must all be provided for before we arrive at the amount per ton actually available as net profit.

We will take as the basis of our calculation a quarry yielding 6,000 tons a year, or the production of about fourteen ordinary bargains.

	s.	d.	£	s.	d.
Gross amount of profit on slates as delivered by the bargainers to the owners, being the average of the results of the nine bargains enumerated . . per ton			2	6	8
Secretary or general manager . . .	1	0			
Manager and two clerks	0	7			
Royalty, $\frac{1}{15}$ on 3*l.* 7*s.* 7*d.* as above . .	4	6			
Average carriage to railway or port . .	3	9			

	s.	*d.*	£	*s.*	*d.*
Loading slates at quarry	0	4			
Discount 2½ per cent. off 20,000*l.*, sales	1	8			
Four machine men, counters, and checkers	0	9			
Rent of wharf and office expenses	0	9			
Six labourers and road men at quarry	1	3			
Carpenter and smith	0	6			
Iron, nails, grease, oil, with other stores for repairs and renewals	0	10			
Removal of top rock or unroofing, and opening loose ends, chargeable to revenue	3	8			
Fund for repayment of capital over term of lease	2	0			
Rates, taxes, and sundry charges	1	6			
			1	3	1
Loading vessels, and shipping clerk, with other wharfage expenses not provided for above, met by the usual shipping charge of 1*s.* per ton					
Leaving net profit per ton of			1	3	7

With reference to these figures I would observe: That if the slates were all valued at present prices, net profit shown would be higher. It will be membered that one of the bargains was worked in 7, one in 1874, one in 1876, and six in the present r. 2. In the example of the underground bargain en, the cost of unroofing and forming loose end, as l as of pumping, is included in the total cost of that gain, and that in the last example two extra urers are charged. 3. On the other hand, if a m-engine has to be employed, an additional sum of ut 1*s.* 9*d.* must be charged for it. 4. The staff I e allowed for is equal to a greater production. f the output be much less, some expenses, as the regular rent of a wharf, will cease, others will be lessened, but the general result will be an increased amount chargeable on each ton of produce. 6. If it be necessary to employ travellers to sell slates, which except in young quarries whose business has to be made it is not, an additional sum must be charged.

It is, I think, now quite clear that if the quarry is, as we are supposing, an ordinary one, there will on the output of 6,000 tons be a net sum available for profit of over 6,000*l.*, or rather more than 1*l.* per ton. Assuming that a quarry equal to a production of 10,000 tons per year has cost, including purchase from original adventurers and other charges, 20,000*l.* altogether in developing up to this point, as per estimates in Chapter XVII., it will be seen that a sum of quite 10,000*l.* would be available as profit.

The prices at which slates are to be sold are fixed annually by the great quarry owners, and followed pretty closely by all the rest. I subjoin two price lists, issued by a well-known quarry company, one for the present year and one for the purpose of comparison, issued for the year 1867, ten years ago. It is hardly necessary to give those for the intermediate years, otherwise they would show the steady advance in the prices of slates from that year until now.

Prices and Particulars of Best Blue Slates, Shipped at Portmadoc, Carnarvonshire.

Dimensions	First Quality		Second Quality		Will cover per thousand About
	Computed to weigh per 1,200	Price per thousand of 1,200	Computed to weigh per 1,200	Price per thousand of 1,200	
In. In.	Tons Cwts. Qrs.	£ s. d.	Tons Cwts. Qrs.	£ s. d.	Sq. Yards
26 × 15	4 0 0	12 15 0	—	—	143
24 × 14	3 10 0	11 5 0	4 0 0	8 15 0	127
24 × 12	3 0 0	9 10 0	3 10 0	7 15 0	108
22 × 12	2 15 0	8 0 0	3 5 0	6 8 0	98
22 × 11	2 10 0	7 10 0	3 0 0	5 12 6	87
20 × 10	2 0 0	6 12 0	2 10 0	5 0 0	72
18 × 10	1 15 0	5 5 0	2 5 0	3 15 0	63
18 × 9	1 10 0	4 5 0	2 0 0	3 10 0	60
16 × 10	1 10 0	4 0 0	—	—	56
16 × 8	1 5 0	3 0 0	1 10 0	2 5 0	44
14 × 8	1 2 0	2 2 6	1 5 0	1 15 0	37
14 × 7	1 0 0	1 15 0	1 2 2	1 7 6	30
13 × 7	0 15 0	1 10 0	—	—	27
12 × 6	0 12 2	0 17 6			
14 × 12	1 12 2	3 5 0	—	—	53
14 × 10	1 7 2	2 10 0	—	—	46
13 × 10	1 5 0	2 5 0			
10 × 8	0 15 0	1 0 0			

22 × 11 and upwards, 5 per cent. off List Prices.

Sept. 1867.

TON SLATES.

			Price per ton.
	£ *s.* *d.*		£ *s.* *d.*
Queens, from 28 to 36 ins. long, and various widths, from . . .	3 0 0	to	4 0 0
Rags, irregular lengths	1 15 0		2 0 0
Moss			1 0 0

SLABS.

Sawn slabs, various dimensions .	2 15 0		3 15 0
Ditto, to order	3 10 0		4 10 0
Ridges			4 10 0

Shipping charges—Slates and slabs, 1*s.* per ton.

All slates are shipped at the risk of the purchaser, and no other allowance made for breakage than sixty slates per thousand on slates sold by tally, and 1 cwt. per ton on slates sold by weight and, as the full tally is invariably put on board, purchasers are requested to claim the same from the shipmaster.

All orders are entered, subject to the Company's current rate the time of shipment.

Insurance of the cargo will be effected if required, and charg in the invoice.

Terms of payment.—Approved bill at four months from date invoice, or three per cent. discount for cash.

Prices and Particulars of Best Blue Slates Shipped at Portmadoc, Carnarvonshire.

Dimensions	First Quality						Second Quality						Will cover per thousand About
	Computed to weigh per 1,200			Price per thousand of 1,200			Computed to weigh per 1,200			Price per thousand of 1,200			
In. In.	Tons	Cwts.	Qrs.	£	*s.*	*d.*	Tons	Cwts.	Qrs.	£	*s.*	*d.*	Sq. Yards
26 × 15	4	0	0	16	15	0		—			—		143
24 × 14	3	10	0	15	5	0	4	0	0	11	17	6	127
24 × 12	3	0	0	13	0	0	3	10	0	10	5	0	108
22 × 12	2	15	0	11	15	0	3	5	0	8	12	6	98
22 × 11	2	10	0	10	15	0	3	0	0	8	2	6	87
20 × 10	2	0	0	9	0	0	2	10	0	7	10	0	72
18 × 10	1	15	0	7	7	6	2	5	0	6	0	0	63
18 × 9	1	10	0	6	5	0	2	0	0	5	0	0	60
16 × 10	1	10	0	6	5	0		—			—		56
16 × 8	1	5	0	5	0	0	1	10	0	3	15	0	44
14 × 8	1	2	0	3	12	6	1	5	0	2	15	0	37
14 × 7	1	0	0	3	2	6	1	2	2	2	10	0	30
13 × 7	0	15	0	2	15	0		—			—		27
12 × 6	0	14	0	1	7	6		—			—		20
14 × 12	1	12	2	5	10	0		—			—		53
14 × 10	1	7	2	4	15	0		—			—		46
13 × 10	1	5	0	4	2	6		—			—		44
10 × 8	0	15	0	1	10	0		—			—		24
10 × 6	0	10	0	1	2	6							

Dec. 1876 for 1877.

TON SLATES.

	Price per ton. £	s.	d.
Queens, 28, 30, 32, and 36 inches long, various breadths, assorted	4	4	0
Ditto, any 3 sizes	4	7	0
Ditto, any 2 sizes	4	10	0
Ditto, any 1 size	5	0	0

Shipping charges.—Slates and slabs, 1*s.* per ton.

Charges on slates sent by rail.—1*s.* 3*d.* per ton.

All orders are entered, subject to the Company's prices and erms at the time of shipment.

All slates are shipped at the risk of the purchaser, and no other llowance made for breakage than sixty slates per thousand on lates sold by tally, and 1 cwt. per ton on slates sold by weight.

Insurance of the cargo will be effected if requested, and charged n the invoice.

No credit can be given on any less quantities than 50 tons t a time, except to customers who are in the habit of keeping arger accounts on the books.

Terms of Payment.—Approved bill on London, at four months rom date of invoice, or three per cent. discount for cash on eceipt of invoice, or 15*s.* per cent. per month.

Production of a Bargain in the Slate Quarry in the Llangollen District before referred to, for Five Months, inclusive of Loss of Time by Men, Stoppages, &c.

Sizes	Poundge.					Total	Approximate weight			Approximate value at 1875 prices			Approximate results and remarks
	10s. 1st month	10s. 2nd month	15s. 3rd month	15s. 4th month	15s. 5th month		Tons	Cwt.	Qrs.	£	s.	d.	
Inches													
24 × 14	860	600	960	660	1,060	4,140	16	10	0	51	15	0	
24 × 12	2,560	1,560	860	1,400	1,460	7,840	27	10	0	80	15	6	Average production per month, 38 tons
22 × 12	1,200	760	860	760	760	4,340	13	15	0	41	15	9	
22 × 11	1,660	1,300	500	560	760	4,780	11	18	0	36	7	6	Average weight per thousand, 2 tons
20 × 12	500	200	460	260	160	1,500	4	2	2	12	15	0	
20 × 10	3,760	2,500	2,060	2,160	1,560	14,040	31	10	0	98	6	0	
18 × 10	1,900	1,560	1,260	1,400	1,060	7,180	15	2	0	43	15	0	Or weight of 20 × 10
18 × 9	1,600	1,260	600	800	600	3,860	7	10	0	20	5	0	
16 × 10	1,400	900	1,100	1,060	860	5,320	10	0	0	27	18	6	Average price per ton, 2*l.* 16*s.*
16 × 8	2,260	1,500	1,200	1,200	1,000	7,160	10	0	0	28	13	0	Average price per thousand, 5*l.* 12*s.*, or about the price of 18 × 9 seconds.
14 × 10	900	660	760	700	800	3,820	5	15	0	15	0	0	
12 × 10	700	400	760	160	1,060	3,080	3	17	0	7	14	0	
14 × 12	100	60	200	400	160	920	1	15	0	4	0	0	
14 × 8	960	660	660	500	660	3,440	4	3	0	10	15	0	
14 × 7	1,000	360	560	500	560	2,980	3	5	0	7	15	0	
13 × 8	—	—	100	—	100	200	0	4	0	0	13	0	
13 × 7	60	—	—	—	100	160	0	2	2	0	9	6	NOTE. — The number of Randoms made on this 'Bargain' reduces the weight and value of the slates.
12 × 8	—	—	—	—	200	200	0	3	3	0	8	6	
Randoms	4,760	3,130	4,760	2,760	3,000	18,410	23	0	0	18	8	0	
							190	2	3	507	9	3	
Add 7½ per cent. to bring to price of 1876										38	1	2	
										545	10	5	

rticulars of Slates made from Two Bargains in one of the Festiniog Quarries, June 1877.

s	Rate per M. of 1,200	Bargain No. 7 New Vein	Bargain No. 2 Old Vein	Results and remarks
es	£ s. d.			Total produce of New Vein, 32,050 slates Total produce of Old Vein, 42,860 slates Computed weight of slates from New Vein, 66 tons Computed weight of slates from Old Vein, 87¼ tons Average weight per thousand in each case, slightly over two tons The proportion of seconds to best in the Old Vein is less than one-twentieth That of the New Vein less than one-fifteenth Or the proportion of seconds slates to best is one-fourth higher in the New Vein than that of the Old Vein The low average weight of the slates in both these instances is due to the excellence of the cleavage in these two 'veins'
15	1 12 6			
14	1 10 0	2,500	2,600	
12	1 7 6	4,000	8,250	
12	1 8 0	1,500	1,250	
11	1 2 6	2,000	1,800	
10	1 0 0	9,100	8,600	
10	0 17 6	2,650	2,200	
9	0 12 6	1,200	2,700	
10	0 15 0	1,900	2,350	
8	0 10 0	2,200	4,450	
8	0 7 6	800	1,400	
7	0 6 0	700	1,400	
7	0 5 0	100		
6	0 4 0	150	500	
12	0 12 0			
10	0 11 0	750	1,150	
10	0 10 0	150	460	
8	0 6 0	500	1,900	
6				
ND ITY		30,200	41,010	
12	1 0 0	350	150	
12	0 18 0	—	50	
11	0 17 0	200	50	
10	0 15 0	650	450	
10	0 12 0	150	200	
9	0 10 0	150	200	
8	0 7 6	250	500	
8	0 6 0	50	200	
7	0 6 0	50	50	
		1,850 30,200	1,850 41,010	
		32,050	42,860	

CHAPTER XXI.

ON SOME OF THE CAUSES OF FAILURE IN SLATE QUARRY ENTERPRISE.

It would be vain to attempt to conceal the fact that failures, and some of them lamentable ones, have occurred in the progress of slate quarry enterprise. One of the evidences of this is the number of abandoned holes and heaps that dot the hill-sides of Wales. It may help to reduce the number of such failures in the future, if I briefly enumerate some of the causes by which such failures have been produced in the past.

These may be broadly divided into four groups: first, want of knowledge; secondly, want of means; thirdly, want of energy and judicious management; fourthly, real and insuperable defects in the rock. The whole of these causes dovetail into each other, and in some instances of failure, it would be difficult to assign to each of them its proper share of the blame.

First, want of knowledge.—It should be observed at the beginning, that slate quarrying is a comparatively new enterprise, and that with the exception of one or two quarries, anything approaching to the systematic working of a quarry belongs to a very recent date. The trade has had to be learned, and it is only reasonable to expect that it would be subject to the proportion of the mistakes arising from immature knowledge, that mark the early history of all great industries. The present race of quarry managers will not deem it a personal allusion, when I say, that in time past there has not only been an indifference to the acquisition of the simplest elementary scientific knowledge on the part of former managers, and indeed, proprietors also, but a large amount of hostility to the intrusion of science into their special so-called practical domain. There has been a good deal of open sneering at 'scientists,' 'theorists,' and 'all the members of the Geological Society put together.' It is beginning to be understood, however, that it requires one set of gifts to catch the hare, and another set of gifts to cook it well, and the luckiest man is he who possesses the two kinds of qualifications. It is felt increasingly that a manager may work his quarry all the more successfully if he possesses a knowledge of the stratigraphical position and conditions of the rock in which it is placed. Among the results of the want of this knowledge may be instanced, the opening of quarries where they ought never to have been started, and the prosecution of them under unfavourable conditions, beyond the first simple trials necessary to prove the character of the rock. Examples of these failures may be seen in broken and contorted strata, near Snowdon, in the cross cleaved strata near Tremadoc, Glasllyn, and Llanfrothren, and in the highly pyritised

Lingula flags, south of the Barmouth estuary. In all these districts, abandoned quarries mark past failures, the loss in which, with greater knowledge possessed by the originators, would have been limited to the comparatively small amount needed to prove the strata.

Failures from want of means.—As in all other enterprises so in this failures arise from the want of sufficient capital for the completion of the works. An adventurer, or two or three begin a quarry at a prosperous time, in the hope of developing out of their savings; reverses come, they are unable either to hold or sell, and the undertaking passes away from them. Or the money that should suffice for the development of the quarry, has been spent in outside works that might at least have been postponed. Sometimes this happens on a large scale, by the lavish expenditure of money on engineering and external appliances, before the quarry is opened fairly out. Take an example: I have before me an instance of a large and intrinsically good quarry that at this moment is lying idle from this cause. It is a story of 120,000*l.* spent on houses, machinery, splendid buildings, massive masonry, and a costly railway, followed by an exhaustion of funds, the death of some of the proprietors, the unwillingness or inability on the part of the remainder to find the money still required, partial abandonment; subsequent letting to men of smaller means, who pick out the eyes of the quarry; further deaths, private losses, dilapidations, bad to worse, quarry acquires a bad name, and becomes a gigantic ruin. Thus want of means results sometimes from want of management. It should be laid down as a rule, that a quarry should not be prosecuted beyond the preliminary stage, unless sufficient means are secured for its development, and the completion of the works necessary to it.

Want of management.—A large number of failures seem to have arisen from this cause in time past. Generally there has been no definite plan of operations. A hole has been excavated, or a tunnel driven in slate rock at the point at which it has been discovered, without the least idea on the part of the adventurers whether it was at the top, or bottom, or middle, or under or upper side of the bed, and the débris has been pitched indiscriminately on the outside, often on the very best of the rock, which by subsequent workers can only be reached by removing at great cost the rubbish of their unfortunate predecessors. Some of the principal quarries in Wales are now suffering from this want of former management. Take an example: a large quarry covered with former débris which has to be removed; good slate rock; owners having paid a large price for the quarry, anxious to secure good profits; waste overhangs quarry, falls now and then, entailing a great cost for its removal; stoppage of good bargains, failure of others; money wanted, if it could not be forthcoming quarry would have to be abandoned. There has often been the same want of management in the working of a quarry: stuff removed twice over, too much day work, desultory experiment, doing and undoing; not sufficient care taken to see that the rock was properly quarried, wisely cut, or good blocks that would make slates 16 × 10 and under thrown upon the rubbish heap; want of close attention on the part of both owners, or directors and manager, the want of energy, and the defects of character, which ruin men in other lines of life. All these, in many forms of combination, have contributed to the failures of slate quarry enterprise.

It is only fair at this point to observe that most of the successful quarries in North Wales have passed through times of depression, and even of abandonment for years, through failures arising from the two last causes. It has taken great efforts and the expenditure of large sums of money to develop both the Penrhyn and Dinorwig Quarries into regular galleries successfully worked, out of the inchoate mass of rubbish, heaps, and holes, left by former workers. The Cilgwyn Quarry lay in an abandoned state for centuries before, and years at times in the present century. Hafodywern was overgrown with grass in 1825. Bowydd Quarry, now successfully worked by Mr. Percival, was abandoned by Mr. Greaves, in 1846, as worthless; and a similar story of stagnation, disrepute, and loss, could be told of many others now in successful work. The failures have not been from inherent defects in the rock, but from want of knowledge, energy, tact, management, and the like, on the part of men.

Failures from unexpected alterations in the charac-

ter of the rock.—There are instances of failure from this cause. The rock becomes changed in character, gritty, coarse, or hard, or clusters of spar veins are seen to spring, and cut the bed into fragments, and if the space allotted to the quarry be limited, if the quarry be opened *across* the bed, instead of *along*, as is sometimes partly unavoidable, the result is loss, which if the funds be good may be tided over, but sometimes stoppage and abandonment. Still failures from causes that could not be foreseen are not of frequent occurrence, and some of these could probably be avoided if the quarry had not been opened in some cramped corner where it was impossible to give such variations in the character of the rock a wide berth. In all large quarries there are such variations. I daresay it would be possible, both at Penrhyn and Dinorwig, to pick half-a-dozen places at least in the quarries, where if a small quarry only had been opened, it could not be profitably worked for dykes, posts, crychs, spar veins, and hardened rock. In a quarry of sufficient breadth, such defects only form part of the mass of rock, their removal simply lessens the profit from the working of the remainder for a time, and after a time they disappear.

The chances of failure from the foregoing causes and from their combinations may be lessened. 1. By avoiding, in North Wales at least, opening quarries in the Lingula flags. 2. By avoiding the heart of the cross cleaved district. 3. By choosing the site of a quarry on a line of unfaulted strata, or at any rate by avoiding localities known to be much broken and disturbed by faults. 4. By having as far as possible the galleries and chambers formed along rather than across the strike of the slate beds. 5. By carefully conducting the preliminary trials or seeing that they have so been conducted. 6. By avoiding day work, and by having a strict system of weighing and measuring. 7. By having a careful survey and section of the ground, as well as a definite plan of working, prepared before the works are commenced. 8. By one or other of the owners or directors residing near the quarry and being much on the works, after the fashion of the most successful quarry owners of Wales. If these cautions and precautions are carefully observed, most of the risks of failure will be avoided, and the remainder will be confined to the expense incurred in the preliminary trials. As a matter of fact, many quarries in North Wales have cost more money than that provided for in my estimates given in Chapters XIV. and XV., but the excess over those amounts may generally be assigned to one or more of the causes which I have just described.

CHAPTER XXII.

RISE AND PROGRESS OF THE SLATE TRADE.

THE earliest indications we have of the use of slates for covering buildings belong to the twelfth century of the present era. To that and slightly subsequent dates belong the old castles of North Wales which, as at Carnarvon and Conway, were built in the vicinity of slate rocks and covered with slates. So was also the old castle at Angers in France, built as it was in the vicinity of the slate beds now so largely quarried underground.

When Edward I. visited the copper-mines of Drwysycoed in North Wales, he stayed at a house in Nantlle roofed with slates from the Cilgwyn Quarry.

It is likely that the slates in all these cases were rough and heavy, being obtained with little trouble where the slate rock cropped out to the surface and was readily divisible into rough blocks. On the mountain slopes of North Wales on several of the slate ranges, as described in this book, there are traces of these old workers, and the tracks along which they carried on their own backs, or the backs of their horses, the rough slates they had made, are still discernible, and form part of many a mountain path. The shepherd tending his sheep in these lonely wilds would generally be the first discoverer of the slate beds, and thus, as in other lines of life, the quiet contemplative man went before and prepared the way for the busy worker. In an ode written by a Welsh poet in the year 1570, we find the first distinct mention of the Penrhyn Quarries. The bard Sion Tudor asks the Dean of Bangor for a load of slates from the Caehir Quarry. The Aberllefeni Quarry is quite as ancient, for an old timbered house is said to have been covered with slates from the quarry in the days of Elizabeth. About the same time the slates from the De la Bole Quarries, in Cornwall, had attained considerable repute both at home and abroad. Carew, writing in 1602, describes them as ‘in substance thinne, in colour faire, in waight light, in lasting strong, and generally carrieth so good regard as (besides the supply for home provision) great store is yearly conveyed by shipping both to other parts of this realm and also beyond the sea into Britaine and Netherland.’ Speaking of the same quarry in 1758, Borlase writes: ‘That for its lightness and enduring of weather it is generally preferred to any slates in Great Britain.’ He describes the great quarry as in his time 300 yards long and 100 yards wide, and 80 yards deep; observing ‘That all the slate is carried, with no small danger, on men’s backs, which are guarded from the weight by a leather cushion.’ It is evident, from the size of the quarry, that a considerable quantity of slates had at that date been extracted from it.

The quarries at Llangynog and in Glynceiriog belong to quite as early a date, for Leland tells us that Oswestry, when he was there in Henry the Eighth's time, says that the houses of the town were principally formed of timber and slated, and it would be from those districts nearest to the town that the slates would be derived.

In the years 1800-10 the quarries of Llangynog disposed of about a million slates, or 2,000 tons annually, or equal to the present production in weight. Up to the year 1803 the slates sold for 13*s.* per 1,000; from 1803 to 1810 they sold for 16*s.*

In the year 1765 we find the site now covered by the Penrhyn quarries let in small takes to eighty men, who each paid a rental of 1*l.* a year. In 1780 the produce of these quarries was 1,000 tons a year.

In 1793, Richard Pennant, having previously married the daughter of General Warburton, the former owner, became possessed of the quarries, the men's leases having expired. In that year he had 150 men at work, opening out the quarry for extended operations. In 1808, in spite of the heavy war-tax of twenty per cent. which the Government had imposed on slates exported from this country, he had 600 men at work. For a time this tax had a prejudicial effect upon the trade of the quarries, for the exportation fell from 15,000 tons in 1794, to 8,000 tons in 1796. In 1800, the tax having in the meantime been abolished, the exports had risen to 20,000 tons.

Bingley, who had just before visited the quarries, describes them as 'immense openings, with sides and bottoms, as rude as imagination can paint'; but at that date he describes Port Penrhyn as 'principally used by vessels coming for the slates obtained from Lord Penrhyn's quarries, about five or six miles distant. About 600 tons are shipped per week. These, for many years, were conveyed to the port, at an enormous expense, by means of carts and horses, from 100 to 120 teams; but now there is an iron railroad, which extends all the way from the quarries.' In the eighty years that have elapsed since Richard Pennant had 150 men employed, the number has increased to 3,000. Besides the production of ordinary slates, Richard Pennant established a manufactory in connection with his quarries for the planing and making of writing-slates. In August 1799, 3,500 dozen lay ready for shipment to London, and without frames, to various parts of the Continent of Europe.

The old Cilgwyn Quarry in Nantlle was revived about the middle of the last century, and passing through many hands and periods of depression, is now largely and successfully worked. In 1798 the quarries of Cilgwyn were described by Warner in his 'Walks in Wales' as 'consisting of perpendicular excavations of different dimensions and depths, some sinking below the earth upwards of 150 feet.' The Dinorwig Quarries at Llanberis began in a humble way in the year 1787. Like those of Penrhyn they were originally worked as small quarries by a number of adventurers, but since the assumption of the lease by the late owner, Mr. Assheton Smith, they have been gradually emerging out of chaos into a great quarry with regularly succeeding galleries. In 1800 the combined produce of the Nantlle and Llanberis Quarries was estimated by the Rev. Walter Davies, in his 'Report on Agriculture in North Wales,' at 40,000 tons. At the same date, 248 vessels were employed at the Port of Carnarvon in the slate trade.

Following on the track of the 'old people' who dug rough slates out of the hill-sides, two quarrymen went from Cilgwyn Quarry in the year 1765 to Festiniog Parish, and there started the first quarry in the district—the Diphwys Casson Quarry. The quarry was worked by them, with the addition of some fellow-workers, until the year 1800, when Messrs. Turner and Casson, two energetic young men from Lancashire or Yorkshire, purchased it. It is from the latter gentleman, not long since deceased, that the quarry takes its present name. The quarry was sold in 1862 for 120,000*l*. The quarry known as Percival's was started in 1801 by the then Lord Newborough. The Rhiwbryfdir Quarries were commenced by Richard Thomas, a workman of Penmachno, in 1816. From this small beginning, chiefly by the energy and perseverance of Mr. Samuel Holland, the present member for Merioneth, have grown the great quarries known as the Welsh Slate Company (in which the late Lord Palmerston was interested), Hollands, and Mathews. Many quarries now in work date from the beginning of the present century, the workings being fitful and often suspended. The old Bwlchygroes Quarry, near Llanberis, had a great demand for slates for shipment eighty years ago, the vessels loading below Llanwnda. This quarry, like many others, having been idle for years, is undergoing a resuscitation.

The writer of the letters to the 'Carnarvon Herald' gives an interesting picture of the methods of quarrying and transit at Nantlle, at the commencement of the present century: 'The stones were smashed up with a hammer without any rule; any piece of rock which happened to be anything like a slate was made use of, but at least half of the good rock was thus destroyed . . . The men at that time took contracts from the landowners, paying two guineas royalty per annum for the privilege of quarrying the slates. Each man dug a hole where he thought proper, and many of the quarries to this day are suffering from the heedless way in which the holes were excavated and the rubble disposed of, usually thrown out close to the hole upon the good vein. . . . The slates were transportable from the pits upon iron hooks, laid across horses' backs, to a place called Voryd, upon the seashore below Nantlle, where the old rubbish-heaps are still to be seen. . . . The rubbish from *the pits* was conveyed away in wheelbarrows and in bags upon the backs of the men.' The writer received the information from an old inhabitant of the district. In connection with the development of slate quarry enterprise in Nantlle, the names of Mr. Garmons and Mr. Curling deserve especial mention.

From the early Festiniog quarries the slates were carried on horseback to Conglywal, then carted to a place on the river below Maentwrog, where they were put on barges and carried down to the sea, and there transferred to larger vessels. Gradually, roads were made and bridges built. About 1833 a tramway was laid down to Portmadoc. Horses were employed until about fifteen years ago, when, through the exertions of Mr. C. E. Spooner and other gentlemen interested in the district, steam was introduced, and the line opened for passenger traffic. An interesting account of the whole story of this remarkable little railway may be read in the 'Gossiping Guide to Wales.'

The methods by which the slates were brought down the hill-sides from the quarries were at that date of the most primitive description. Bingley says, that at what is now the great Dinorwig Quarry at Llanberis, 'the men, in conveying the slates down to the lake, are under the necessity, as well as one horse before the cart, to have one yoked behind.' He adds, 'It appears to me, however, that sledges similar to those adopted in many parts of Westmoreland and Cumberland (where slate quarries were then in work) for the same purpose, would not only be less expensive, but would also be found more safe and commodious.' What would the present manager of the quarry say to this? The same writer describes another kind of sledge, as it was then used at the Llangynog quarries.

'The slates are loaded on small sledges, which are to be conveyed down the mountain along winding paths formed for the purpose. Each of these sledges has a rope, by which it is fastened to the shoulders of the man who has the care of conveying it. He lays firmly hold of it with his hands, and thus, with his face towards the hill, begins to descend. The velocity which the sledge acquires in its descent is counteracted by the man's striking forcibly against the protuberances with his feet. This manœuvre, since he goes backward, and has at the same time some attention to pay to the sledge in order to keep it in the track, must be difficult to attain.' I have seen the process in operation at the same quarry within the last twenty years. Mr. Bingley forgot to state that the poor man had to carry his sledge back up the hill for each time he went down; and it was surprising how many times a day the feat was performed. Well-appointed inclines now take the place of these old methods, the one at Llanberi being made soon after Bingley's visit. In 1825 a tramway took the place of the road over the hills to Llanberis; now there is an ordinary gauge railway. A reference to the dates given on the lists of quarries in the leading slate ranges will show decades in which most progress was made. That progress has been the greatest, and the number of improvements have been most numerous, within the last twenty-five years. Coincident with the development of the quarries has been the growth of villages and towns; the cluster of villages around the great quarries of Penrhyn, Festiniog, and Llanberis being remarkable for their size, and the quality of the hotels and public buildings. The villages generally take their name from the chapels they have grown around—as Bethesda, Bethania, Ebenezer, and similar names—which the Welsh like to give to their places of worship.

Of the growth of a seaport in connection with a trade, the town of Portmadoc is a notable example. It has been built within the present century. Its slate quays with their railways and appliances for loading slates are well arranged, and are well worth a visit. It would be difficult to say where the slates sent from this port are *not* taken to. They find their way to all parts of the world, the chief trade being perhaps with France, Belgium, Holland, the ports on the Baltic generally. Large quantities being also sent to America, Australia, and Russia. The same may be said of the other chief ports, Carnarvon, Dinorwig, and Bangor (Penrhyn), but a larger proportion of the slates from these ports are taken to the North of England, Ireland, and Scotland, where they prefer strong slates. America also has a share.

The total production of slates and slabs in North Wales for last year may be estimated at six hundred thousand tons. Probably the total production of slates in the British Isles will not exceed seven hundred and fifty thousand tons. At the present time the profit derived from the whole production may be taken as a million sterling. Taking one-fifteenth as the average proportion of finished produce to the quantity of rock removed, the amount of rock required to yield the above number of tons of slates and slabs each year, is equal to a mass a thousand yards long, five hundred yards wide, and eleven yards deep. The first of the following tables will illustrate the growth of the slate trade from the year 1825, and the second will show the advances made in the prices of slates from the year 1799 to the present time. It also gives the prices of slates in London last year.

Shipments of Portmadoc.

Years	Tons	Years	Tons	Years	Tons
1825	11,396	1842	22,190	1859	58,466
1826	13,136	1843	24,716	1860	65,742
1827	10,290	1844	36,344	1861	59,696
1828	9,940	1845	43,858	1862	66,860
1829	10,464	1846	43,472	1863	76,594
1830	11,232	1847	39,601	1864	81,221
1831	12,211	1848	36,503	1865	89,293
1832	14,561	1849	32,467	1866	96,876
1833	13,975	1850	44,874	1867	113,838
1834	15,330	1851	46,338	1868	116,487
1835	18,113	1852	46,224	1869	125,574
1836	20,749	1853	48,858	1870	108,882
1837	23,966	1854	51,109	1871	121,838
1838	25,107	1855	48,279	1872	132,980
1839	27,935	1856	52,463	1873	144,880
1840	32,922	1857	52,697	1874	142,080
1841	29,067	1858	56,314		

Shipments of Carnarvon.

Years	Tons	Years	Tons	Years	Tons
1844	85,044	1854	91,000	1864	122,339
1845	92,000	1855	84,000	1865	122,934
1846	94,000	1856	88,000	1866	127,190
1847	93,000	1857	94,000	1867	126,443
1848	79,000	1858	96,000	1868	134,375
1849	85,000	1859	103,000	1869	139,559
1850	102,000	1860	102,000	1870	135,029
1851	99,000	1861	115,000	1871	117,058
1852	92,000	1862	115,000	1872	116,454
1853	88,000	1863	115,822		

The Produce of the Dinorwig Slate Quarries.

	Tons.
For the 20 years ending 1870	1,900,550
Produce for the 5 years ending 1866 . .	510,126
For the 5 years ending 1871	517,771

The Penrhyn Quarries.

		Tons
1869	Roofing slates	93,000
	Slabs, &c.	26,000
1870	Roofing slates	91,700
1871	Roofing slates	84,800
1872	Roofing slates	85,500

Prices of Best Slates per Thousand, Shipped at Portmadoc.

Years	24 × 14	24 × 12	22 × 12	22 × 11	20 × 10	18 × 10	18 × 9	16 × 10	16 × 8
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1799	—	3 13 6	—	—	2 2 0	—	—	—	1 1 0
1825	—	7 0 0	—	—	4 10 0	—	—	—	2 0 0
1826	—	7 15 0	—	—	5 5 0	—	—	—	2 5 0
1828	—	7 0 0	—	—	4 10 0	—	—	—	2 0 0
1829	—	6 10 0	—	—	4 0 0	—	—	—	1 15 0
1832	—	7 0 0	—	5 15 0	4 10 0	3 0 0	—	—	2 0 0
1833	—	6 10 0							
1838	—	—	—	5 10 0	4 15 0				
1840	8 8 0	7 7 0	—	—	4 10 0				
1841	—	6 17 6							
1842	8 0 0	6 15 0	—	5 5 0	4 0 0	2 15 0			
1843	8 0 0	—	—	4 15 0	—	2 10 0	—	—	1 17 6
1845	—	7 0 0	—	—	4 10 0	2 15 0	—	2 4 0	
1846	—	7 5 0	5 10 0	5 2 6	4 15 0	3 0 0	—	2 10 0	
1847	—	7 15 0	6 0 0	5 10 0	5 2 6	3 5 0	2 12 6	2 15 0	2 0 0
1850	8 5 0	7 5 0	5 12 6	5 2 6					
1851	7 17 6	6 17 6	5 5 0	4 15 0	4 0 0	—	2 12 6		
1853	8 5 0	7 5 0	5 12 6	5 10 0	4 12 0	3 10 0	2 18 0	2 16 0	
1854	8 15 0	7 15 0	6 0 0	6 0 0	5 0 0	3 15 0	3 0 0	3 5 0	
1855	9 5 0	8 6 0	6 10 0	6 0 0	5 7 6	—	3 5 0	—	2 10 0
1860	9 10 0	8 10 0	6 12 0	6 0 0	5 15 0	3 17 0	3 5 0	2 19 0	2 6 0
1861	10 0 0	8 15 0	7 10 0	6 15 0	6 2 0	4 1 0	3 5 0	3 2 0	2 9 0
1862	10 16 0	9 0 0	7 15 0	7 0 0	6 8 0	4 10 0	3 5 0	3 10 0	2 15 0
1863	11 5 0	9 9 0	7 15 0	7 0 0	6 8 0	4 15 0	3 15 0	8 10 0	2 17 0
1868	11 5 0	9 10 0	8 0 0	7 10 0	6 15 0	5 5 0	4 5 0	4 0 0	3 0 0
1873	11 10 0	9 12 6	8 0 0	7 10 0	6 15 0	5 5 0	4 7 6	4 7 6	3 5 2
1874	12 5 0	10 5 0	8 10 0	8 0 0	6 15 0	5 10 0	4 15 0	4 7 6	3 15 0
1875	13 10 0	11 10 0	10 0 0	9 5 0	7 15 0	6 7 6	5 10 0	5 10 0	4 0 0
1875	14 0 0	12 10 0	11 5 0	10 5 0	8 10 0	7 0 0	6 0 0	6 0 0	4 17 6
1876	15 5 0	13 0 0	11 15 0	10 15 0	9 0 0	7 7 6	6 5 0	6 5 0	5 0 0
London prices, May 1876		19 15 0	17 5 0	—	13 0 0	10 15 0	—	9 7 6	

CHAPTER XXIII.

ON THE CAUSES OF THE RECENT RAPID GROWTH OF SLATE ENTERPRISE.

THE progress made by the slate trade during the last quarter of a century has been very marked and rapid, and with the exception of slight checks given to it during the war in America, the war between Prussia and Denmark, and the war between Germany and France, the progress has been continuous. A reference to the price lists given in Chapter XX. will show that during the last ten years the price of slates has increased thirty per cent. The present state of the trade may be described as one of great prosperity, limited only by the ability to supply the demand. The demand is very far in excess of the supply. As a consequence large and regular customers of the quarries have to place their orders a long time beforehand. Smaller and casual customers cannot be supplied at all. Ships have to wait for a long time at the ports for cargoes. 'We have enough orders on our books to last us for six years,' is a common remark. 'We really cannot take any more orders is another.' Merchants are ready to contract for the whole produce of good quarries. It may therefore be of interest if we inquire into the causes of this recent rapid growth of the demand for slates, and consequent activity at the quarries, in order that we may see if there is a probability of a continuance or a decline of such causes in the future.

Beginning at home, it will be seen that the same period has been marked by a rapid extension of railways all over the country. This has placed slates within the reach of numbers of midland and other towns, from which, except for special purposes, they were virtually unattainable on account of the cost of carriage. A builder from South Shropshire, which is not far removed from the Principality of Wales, told me recently, that twenty-five years ago he had never used a slate. The town of Shrewsbury was at that period a tile-roofed town, while Chester, to which access could be had by water, has been for generations a slated town. Shrewsbury may be taken as a type of most inland towns, in which, except for fancy architecture, slates since the introduction of railways have superseded tiles. Those who knew London thirty years ago, will know how much larger a proportion of its houses were covered with tiles at that date than now. Going there as a youth from a slate district, I remember being struck with the novelty of the appearances of the fluted red tiles, then in use. New erections in it and in the great towns of the kingdom have been covered with slates. Then there are the great towns and villages that have sprung up around great railway junctions and centres of new enterprise and industry in many parts of the country, and the disappearance of the straw-thatched houses in rural districts; thus new markets have been created, and old markets enlarged for the sale of the produce of slate quarries at home.

But these markets would have remained unsupplied with the commodity if railways had not been carried into the heart of North Wales. The opening of the Chester and Holyhead line, and the continuation to Carnarvon with its branches—it is a pity that one from Bangor to Nant Francon is not among them—placed many English towns in communication with the slate district of Carnarvonshire. The extension of the Cambrian system of railways by the Corris district, and Towyn to Portmadoc, opened many more to both the Corris and Festiniog districts. The construction of these railways must ever be associated with the name of Mr. Thomas Savin. To his enterprise, North Wales can scarcely estimate how much she is indebted. The construction of the Ruabon and Bala line has opened up the Llangollen district, and thus the quarries have been placed in direct communication with the users of their produce. The development of the slab trade must also be taken into account as one element of progress. Turning to foreign countries, the same causes have been at work in them, if not on so rapid a scale, yet over a vastly extended area during the same period. The gradual removal of restrictive duties and the formation of reciprocity tarifs, have greatly tended to the increase of the exportation of slates to them. In America towns spring up like mushrooms, only to live longer, and the production of slates in that country is neither of the kind required, or a fraction of the extent of the demand. Scotland and Ireland follow in the wake of our home consumption. And the difficulty is to know where to stop. Few of the causes I have named can be regarded as ephemeral ones. With the increase of population and growth of our general trade, at home and in the colonies, and the simultaneous growth in foreign countries, the demand for dwellings must continue.

What then are the chances of our having to encounter competition. Not very long ago one hundred and fifty picked men were taken from the Bethesda district to America, to work in slate quarries there. Already we hear of cargoes of slate being sent over to this country and sold here. By the courtesy of the sole consignee in Great Britain I am able to give the following particulars of these American slates, which it will be interesting to compare with the foregoing description of Welsh slates, premising however that the question of quality is disputed by British quarry owners; and even if labour were abundant in the districts of the American Continent in which slate is found, the slates of that country so far could not compete with the Welsh slates for lightness, combined with strength. Our exports to America are as large as ever, and many of the men are returning to the old country. The same is true of continental countries. Their quarries have been in work as long as those of Wales: nevertheless our export trade to those countries has grown to its present dimensions. The slates of Ireland, so far, are strong, rough, and heavy. What the western district, to which Mr. Hull directs attention, may do, remains to be seen.

Particulars of American Roofing Slates now offered for sale in England.

PRICE LIST.

Will cover, in square yards with 3-inch lap, about	Computed weight per M. of 1,200, about			Size
	Tons	Cwts.	Qrs.	Inches
127	3	5	2	24 × 14
108	2	16	0	24 × 12
	2	15	0	22 × 13
98	2	10	3	22 × 12
87	2	7	0	22 × 11
96	2	5	2	20 × 12
	2	0	0	20 × 11
72	1	17	3	20 × 10
	1	16	3	18 × 11
63	1	13	2	18 × 10
60	1	10	0	18 × 9
56	1	9	0	16 × 10
54	1	6	0	16 × 9
44	1	3	1	16 × 8
	1	2	1	14 × 9
37	0	19	3	14 × 8
32	0	17	2	14 × 7
27	0	16	0	12 × 8

Terms.—Cash in one month, less 2½ per cent. or (approved) three months net acceptance.

American Green Roofing Slates.

We have in stock, and can deliver at once free on rail trucks (L. & N. W. Rails) at Garston (Liverpool), as follows:—

Net cash on receipt of invoice					
Size	Quantity	Price per M. of 1,200	Size	Quantity	Price per M. of 1,200
Inches		£ s. d.	Inches		£ s. d.
24 × 14	12,000	18 10 0	20 × 10	5,000	11 0 0
24 × 12*	12,000	15 17 6	18 × 12	11,000	11 10 0
22 × 14	5,000	16 16 0	18 × 10	12,000	9 10 0
22 × 12*	16,000	14 5 0	18 × 9	14,000	8 5 0
22 × 11	9,000	12 17 6	16 × 12	3,000	9 15 0
20 × 14	10,000	15 0 0	16 × 10	10,000	8 5 0
20 × 12	10,000	12 17 6	16 × 9	27,000	7 10 0
20 × 11	7,000	11 17 6	16 × 8	18,500	6 10 0

The above are all good strong slates, and approved by all who have had them, and we solicit the favour of your orders, which shall have prompt attention.

* We will allow 2½ per cent. discount on these two parcels (12,000, 24 × 12, and 16,000 22 × 12) to close up sales.

Bangor, Elmira, and Washington American Roofing Slates.

These are now admitted by all the trade to be superior in many and inferior in no respects to the best Welsh slates.

We are permitted to refer to many persons supplied by us.

Samples will be sent, without charge, on application.

Delivery in any quantities (from 1,000 and upwards) of any one or more sizes as may be required by the buyer, in about a month (or earlier) from date of order.

Free delivered on railway trucks or to barge or flat in Liverpool, or freight paid direct from New York (U.S.) to London, Bristol, Hull, or Glasgow.

Breakage at purchasers' risk after delivery to carriers here.

Only on parcels furnished for direct shipment from New York, an allowance of 60 slates over in every 1,200 is made at time of shipment at New York to cover ordinary breakage, and no further claim will be entertained.

It is not for us, however, to be boastful, or neglectful of our own resources, and it is a pity for us to turn away customers from our shores. We may conclude that there is no reason to fear from the cessation of causes hitherto at work, or from the effect of competition, any permanent decline in the demand for our slates for many years—may I not safely say for generations—to come. The best way to meet foreign competition seems to me to be to develop as economically and systematically as we can the slate resources of Great Britain and Ireland. For it is the great insufficiency of the home supply to meet the demand that has tempted foreign competitors to our shores. Can we keep up or increase the supply? Can we go on digging slate rock to the extent mentioned in a former chapter, without coming to the end of our resources? Will there presently be the necessity for a slate commission that there was recently thought to be for a coal commission? Such a commission would doubtless be of much use, but it is not yet time to think of it in the view of a diminution of our slate resources. An examination of the slate ranges described in this volume would show an enormous amount of untouched slate rock. Meanwhile something is being done to render these resources available. The completion of the North Wales Narrow Gauge Railway from Carnarvon to Beddgelert and Bettws-y-Coed, would open up ranges 3, 3A, and 3B. The Bettws-y-Coed and Festiniog Line now being made by the London and North Western Railway Company, will open up the Dolwyddelen and Penmachno end of the range 3c. The construction of the Great Western Line from Bala to Festiniog, will reveal what is worth working in the Arenig end of the range 3D, and will afford facilities for exploring the slate resources of the Cambrian rocks about Trawsfynydd. A railway or tramway up the Tanat Valley would make the Llangynog district a second Festiniog. The same is true of the upper reaches of the Ceiriog Valley; and the district lying between Bettws-y-Coed, and Rhyl, Corwen, and Ruthin, has yet to be tapped for its slate resources. Since the introduction of railways, new quarries are being quietly opened up in the older slate districts, and old quarries long closed, through some of the causes I have specified, are being revived, and with the means of transit, the higher price of slates, the use of machinery, the demand for slabs, and the greater intelligence of the present day, many of them need not again be failures, and it is hoped that many a deserted quarry may again resound with the noise of busy workers.

A noticeable feature of slate quarry enterprise in North Wales is the number of private owners of quarries. The trade has been built up and made what it is, for the most part, by men of high standing, of intelligence and capacity for business, and of indomitable energy also, who have not been above superintending their own quarries, having first mastered the details. They deserve all the success they have gained, and no one need envy them the enjoyment of their princely incomes. They and, perhaps more than themselves, their fathers before them, have had their difficulties, their times of great fear and depression; but they worked on, seeing the ascent from behind the horizon of their struggles of the first faint rays of the rising sun of their prosperity.

Slate enterprise is as fair and promising a field for joint-stock enterprise as any other, perhaps better than mines in far-off regions, but it offers special inducements to young men of vigour and intelligence, who either singly or jointly are possessed of the necessary means, and who would be willing to mind their own business. To them it offers the profitable employment of their time and money, giving to them all the charms of an outdoor life, and a good position among their fellow-men.

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